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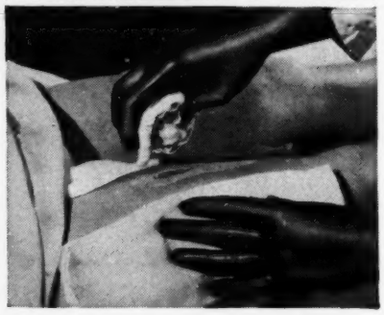

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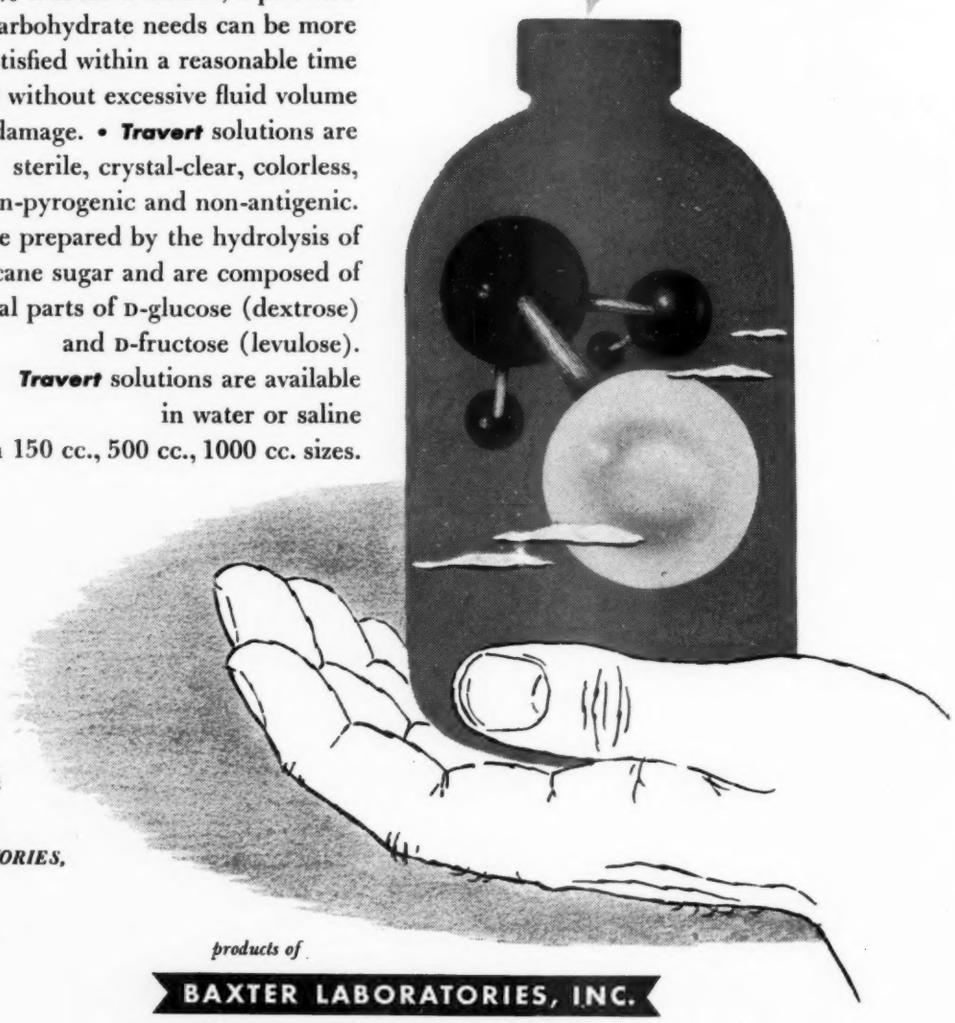

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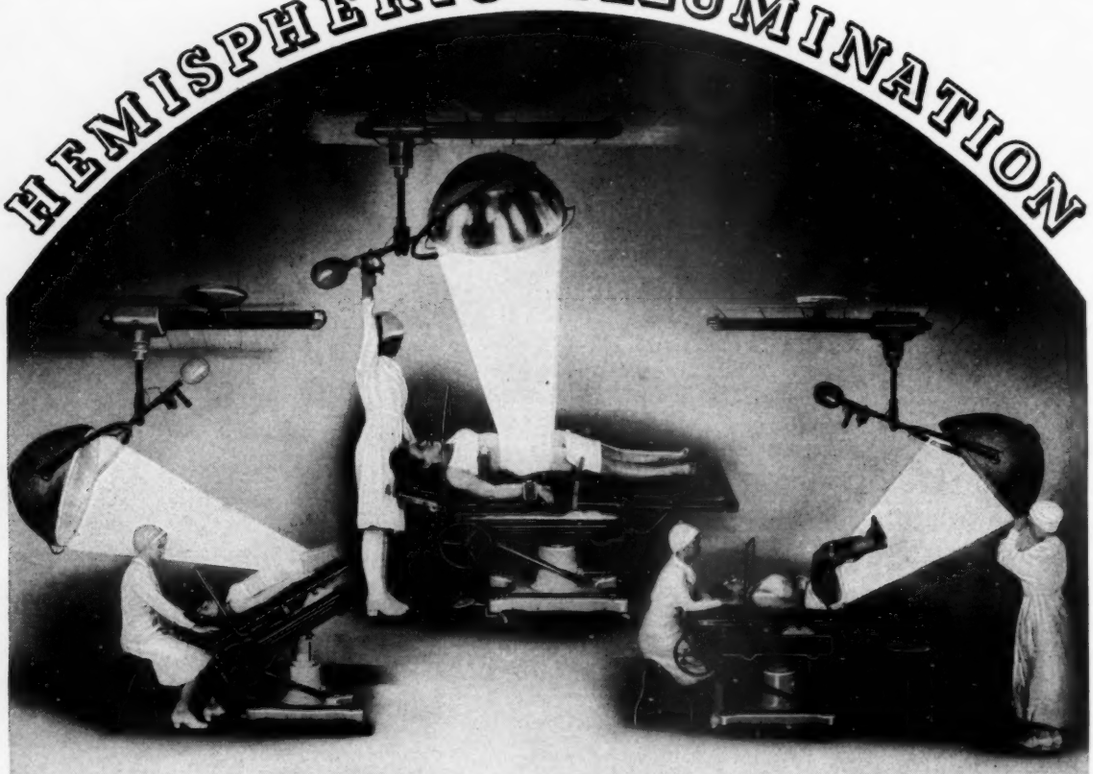

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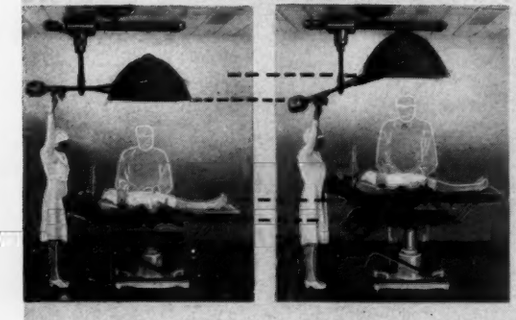

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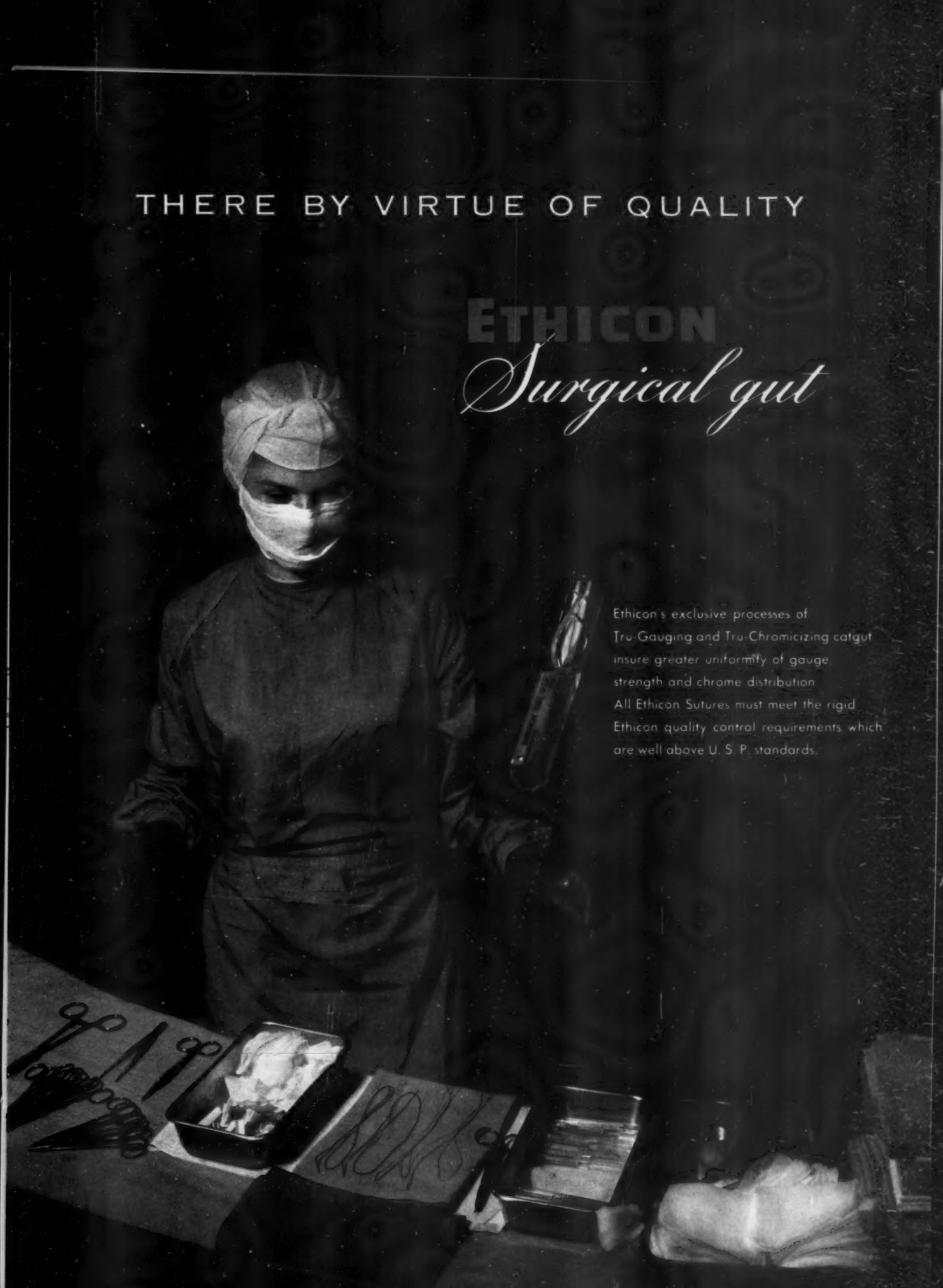

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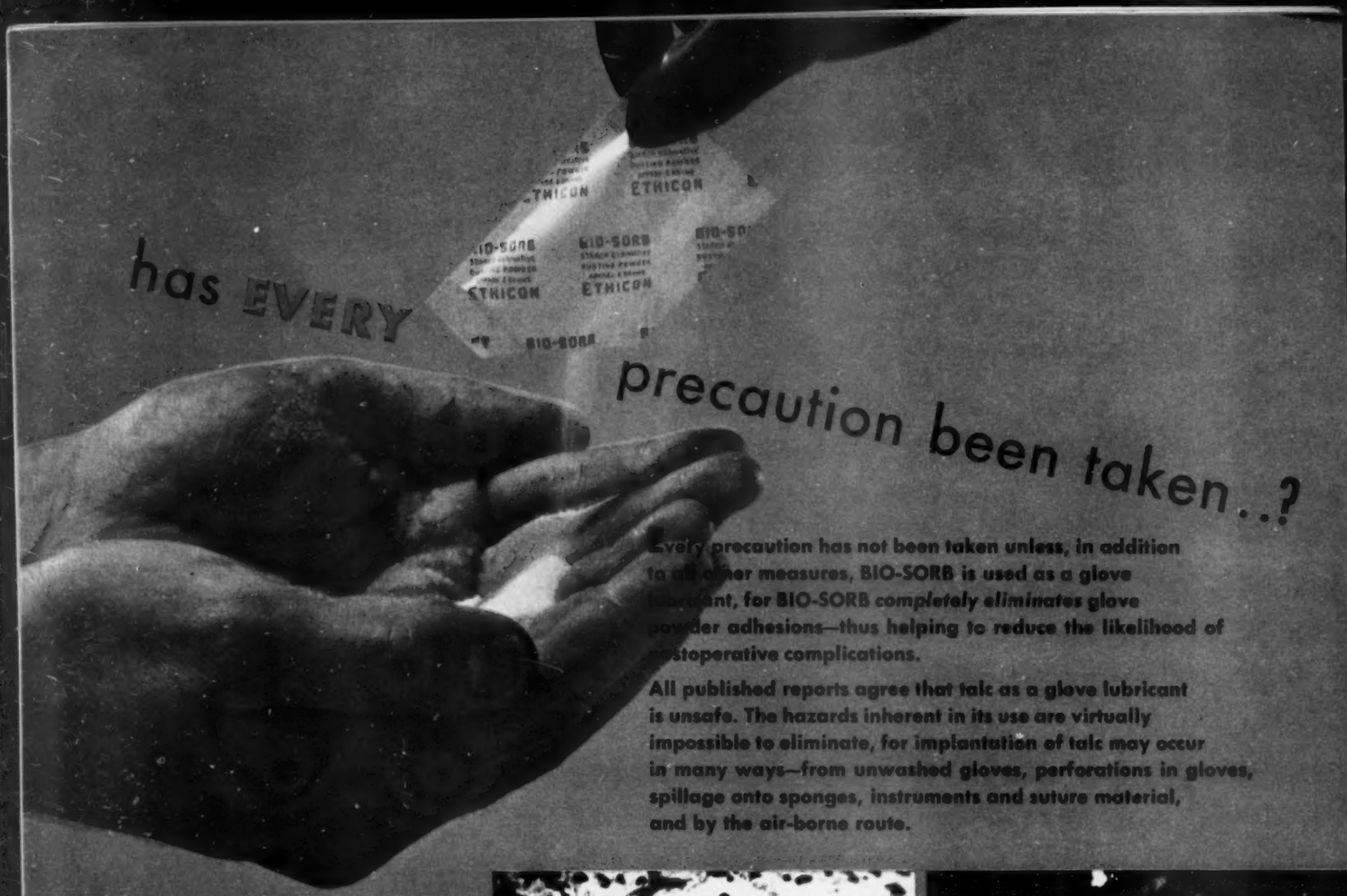

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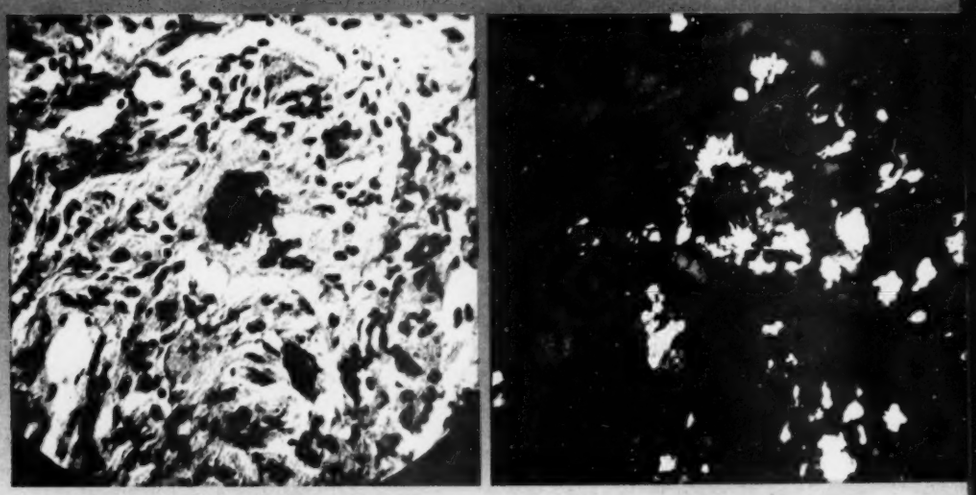

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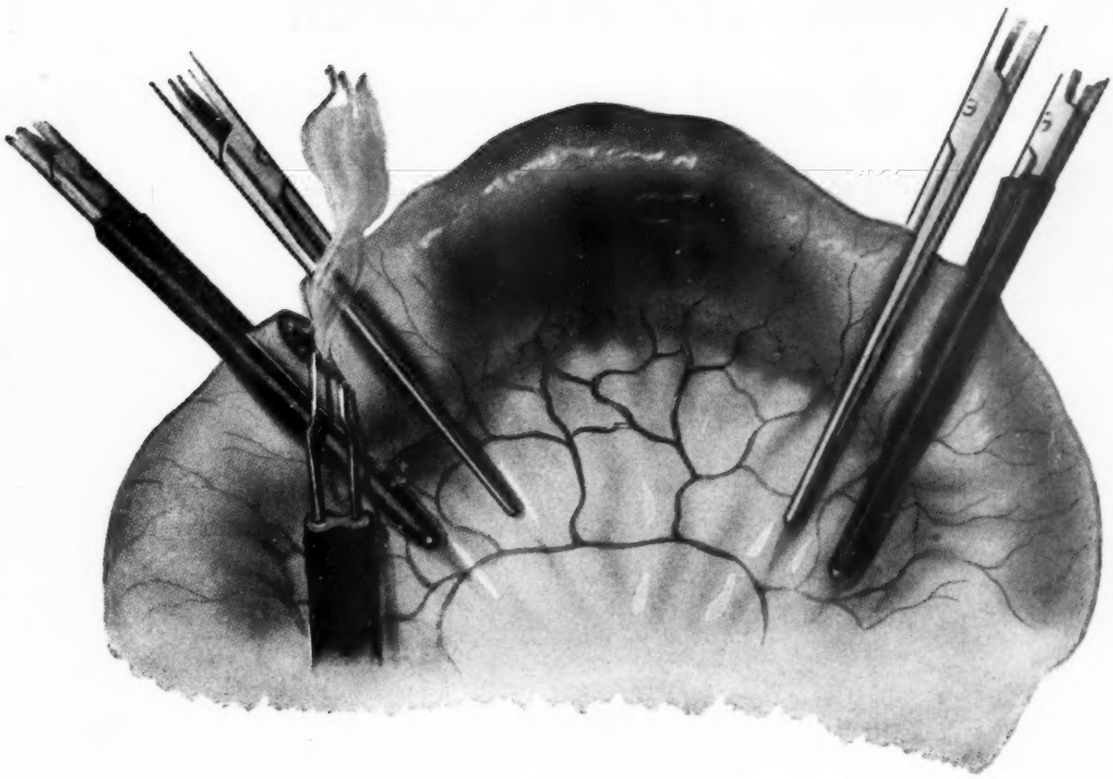

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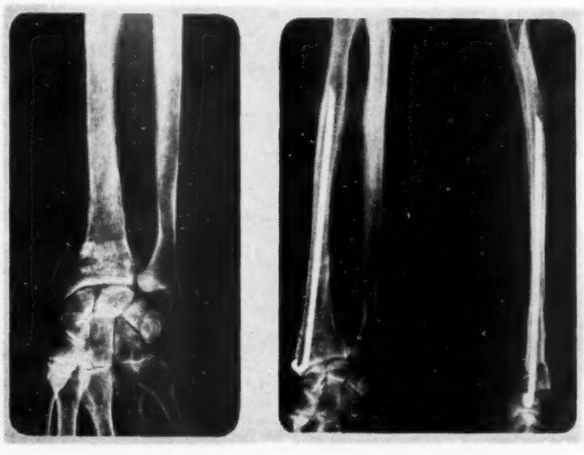

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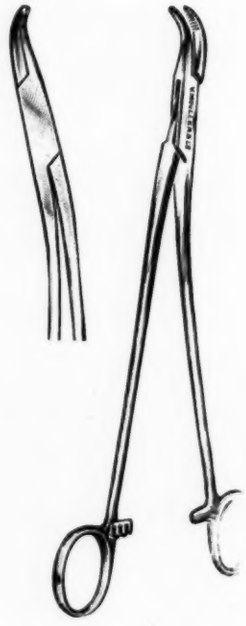

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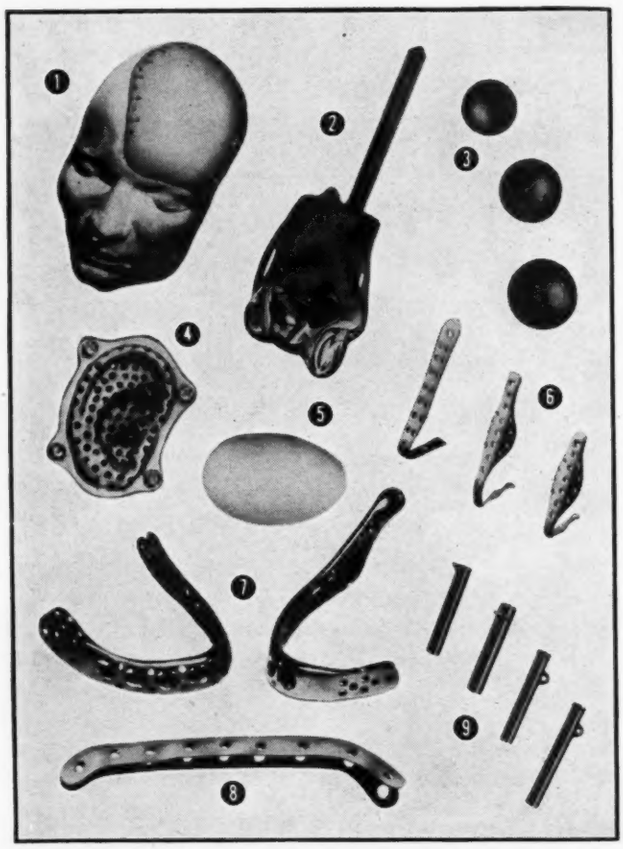

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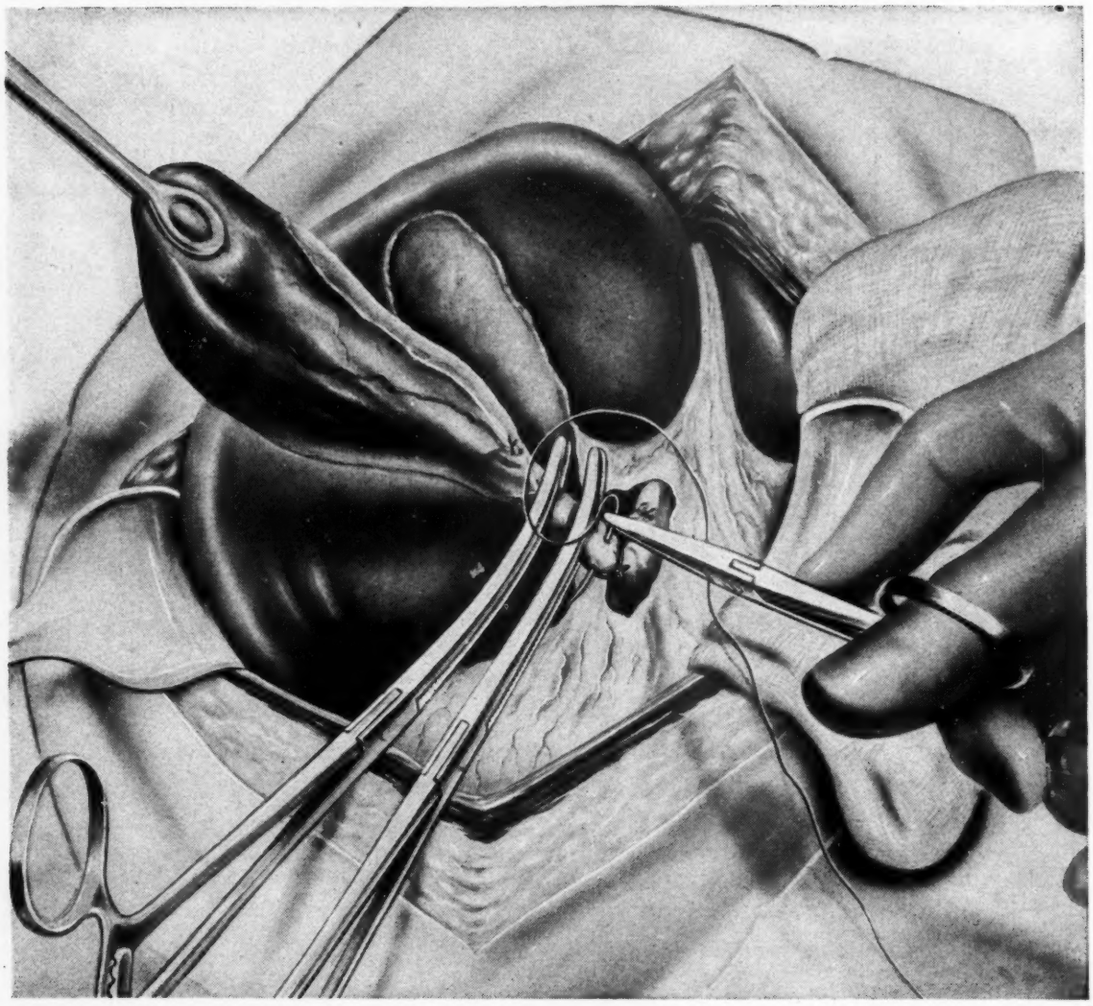

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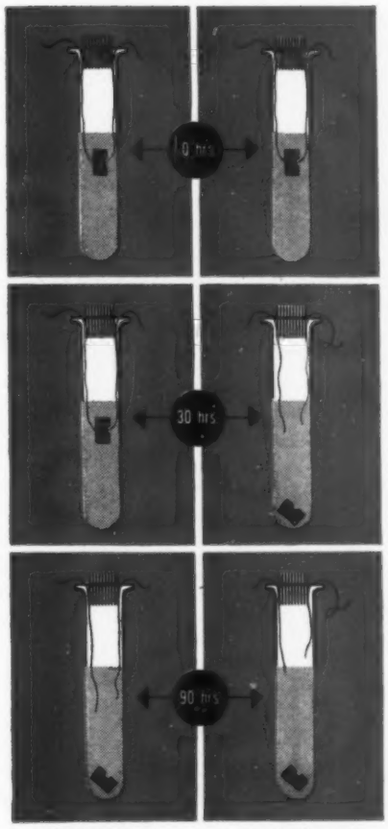

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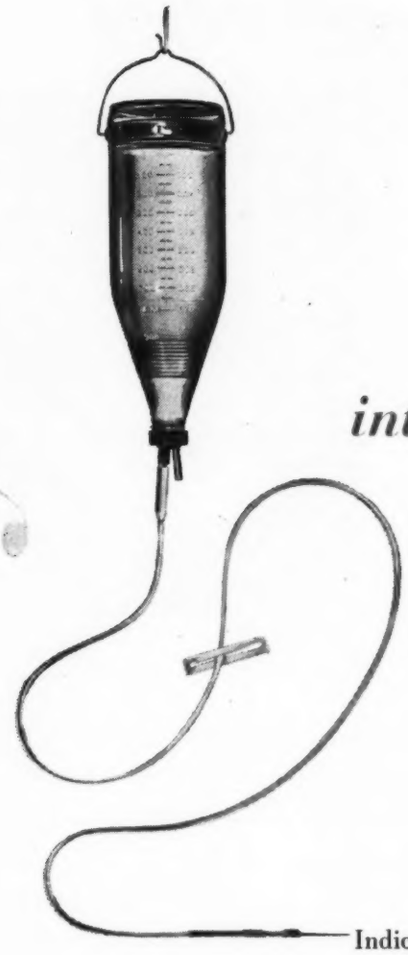

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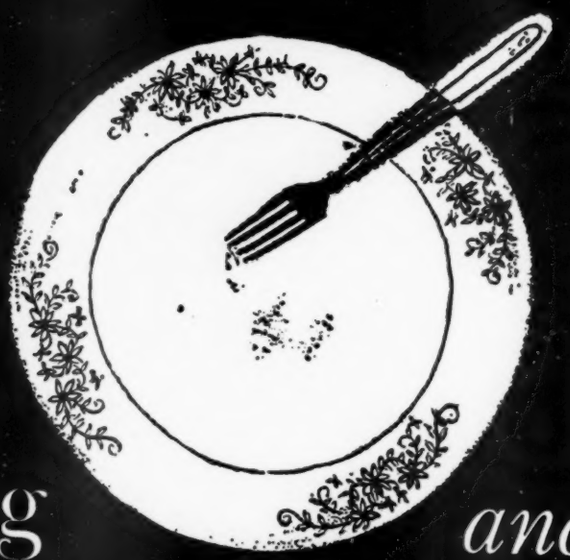

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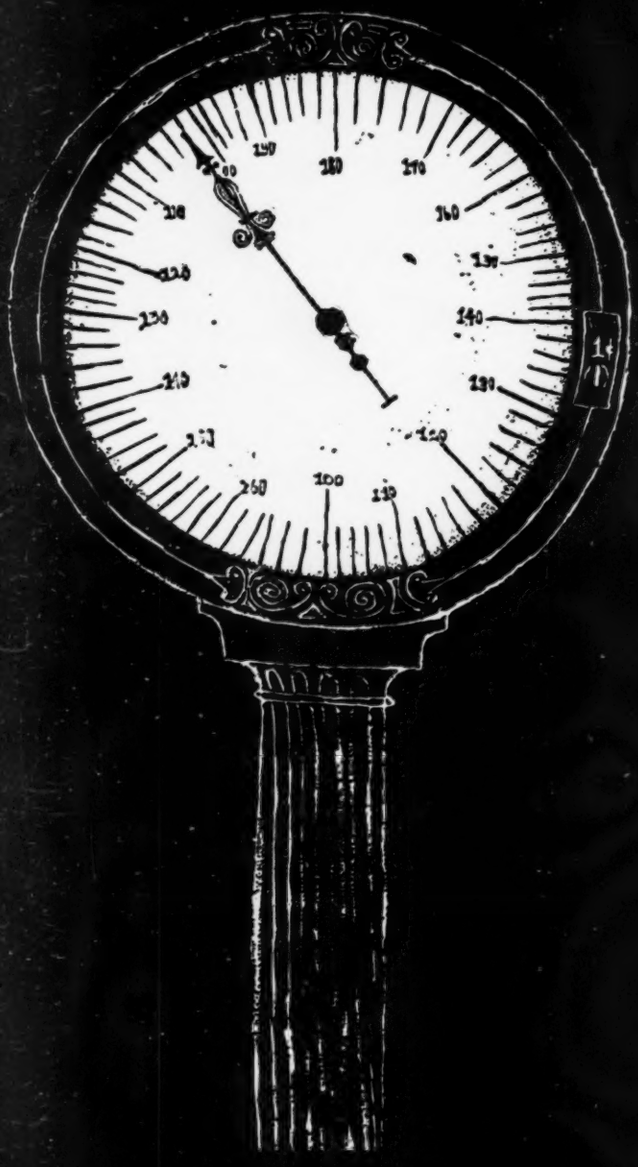

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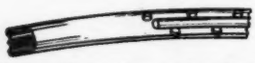

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1. Devine, J. W., and others: Virginia M. Monthly 79:17 (Jan.) 1952
2. Devine, J. W., Jr.: J.A.M.A. 148:115 (Jan. 12) 1952
3. Devine, J. W., Jr., and Morrison, R. L.: Am. J. Surg. 83:396 (Mar.) 1952

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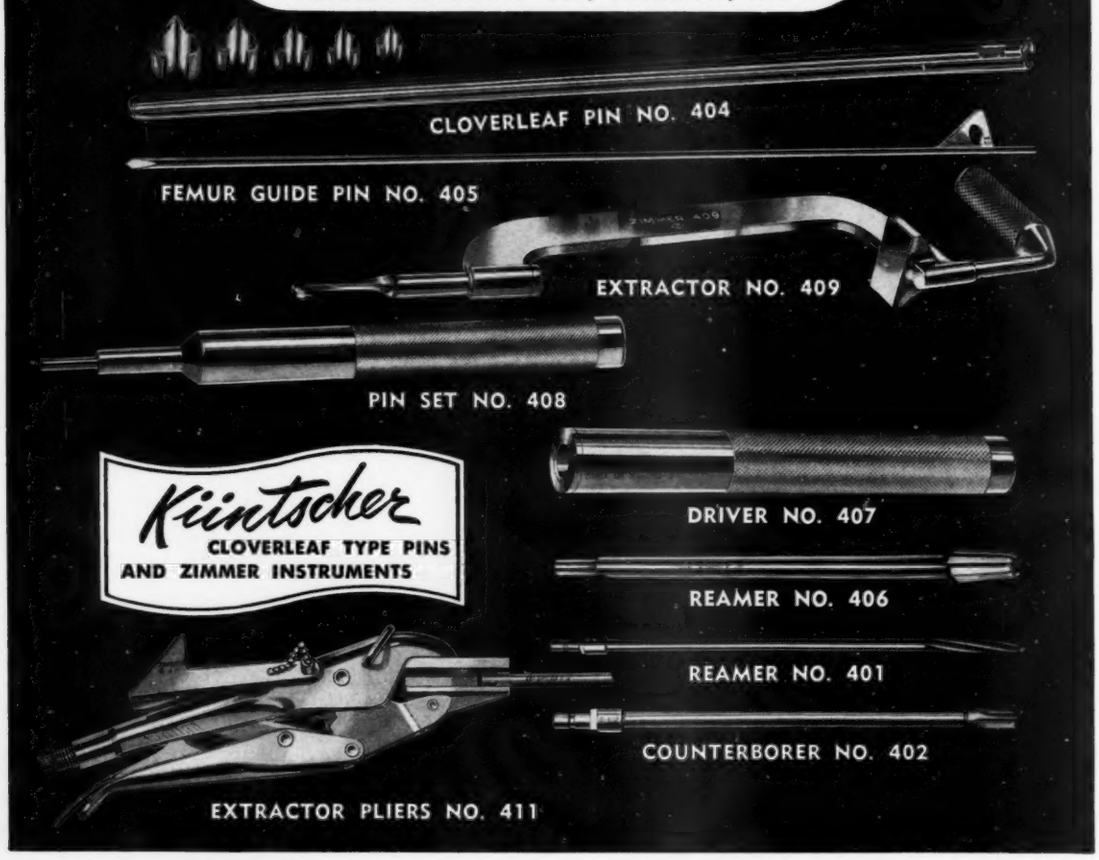

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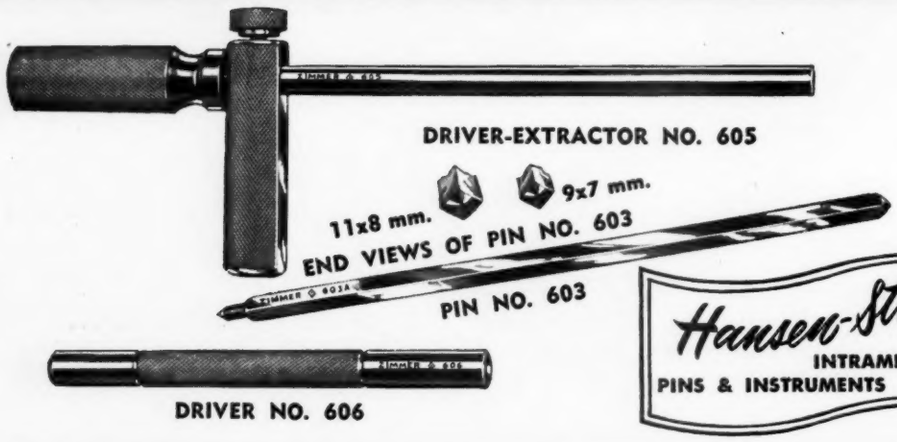

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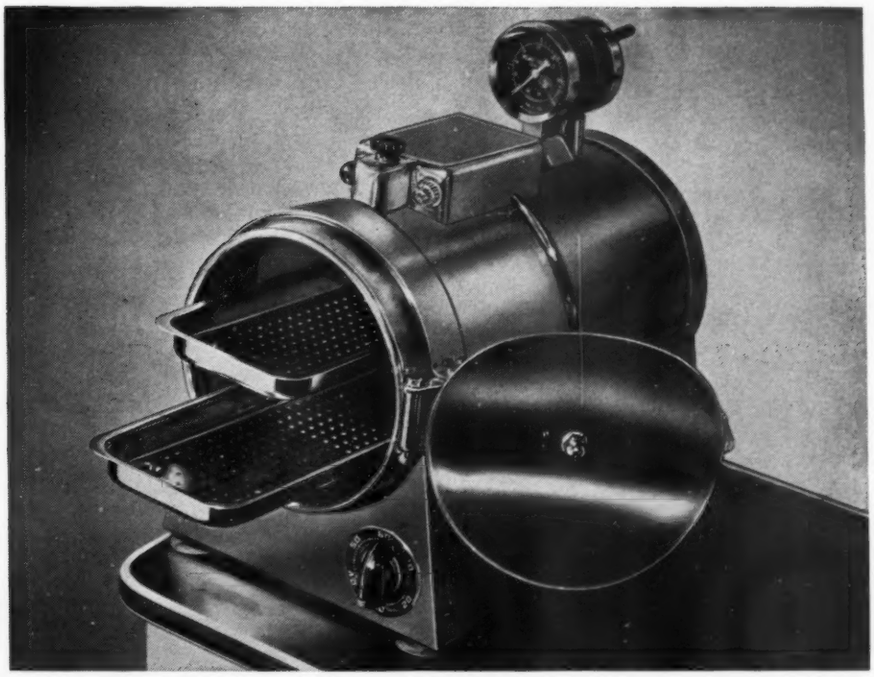

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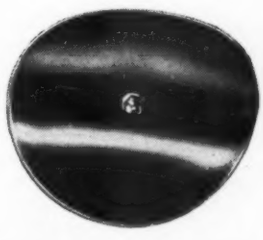

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Sixty-first Year of Publication

VOL. LXXXIII MARCH, 1952 NUMBER THREE

Presidential Address

SURGICAL TEACHING HOSPITALS*

R. Arnold Griswold, M.D.

Louisville, Kentucky

PRESIDENTIAL addresses before associations such as this seem to fall predominantly into two classes, historic dissertations or thoughts on the training of surgeons. This address is of the latter type. Due to a number of factors, not the least of which are the requirements of the American and Royal Colleges of Surgeons and the Specialty Boards, there is general agreement that the residency system is at present the best method of training surgeons. The tangible essentials of modern surgical residencies have been laid down by the Colleges, the Boards and the Council on Medical Education. The intangibles have been discussed in many essays such as this and perhaps best presented by Firor[1] in a recent editorial which deserves close study by all surgeons interested in teaching. In all these publications it is stated or implied that "sufficient clinical material" shall be available for the education of the resident. Pearce[2] was perhaps the first to draw attention to the effect that the present economic situation and health insurance plans have had on residency clinical material. Many endowed institutions have been forced by financial pressure to admit more private and fewer house patients. Insurance plans have likewise made private patients of many who formerly would have been available for teaching purposes. This shortage of teaching material compared to the need for residency training facilities in surgery makes it imperative that we make the best possible use of what is available. The American Board of Surgery[3] states, "The Board realizes that there is not as yet an adequate number of four-year graded residencies (Group 1) to meet the needs of the country for qualified surgeons."

With a few notable exceptions[2,4] there has been little mention of the type of clinical material in the teaching hospitals, a factor which may be quite as important as the amount. Does it represent the surgical ailments of a cross-section of the population; is it balanced as to age and sex, outpatient and inpatient, acute and chronic, major and minor? Has the development of residencies in the subspecialties of surgery, prevalent in most university hospitals, deprived the general surgical resident of training in aspects of

[1] Firor, W. M. A four-year graded residency. *Surg., Gynec. & Obst.*, 93: 496, 1951.

[2] Pearce, H. E. Does medical insurance endanger the resident system of training surgeons? *Surgery*, 22: 165, 1947.

[3] American Board of Surgery. *J. A. M. A.*, 147: 509, 1951.

[4] Zollinger, R. M. The postwar trends in the training of the general surgeon. *Surgery*, 24: 161, 1948.

* From the Department of Surgery, University of Louisville School of Medicine, Louisville, Ky.

surgery which will be necessary parts of his practice? In other words, is the material available that of "run of the mill" surgical practice or is it accidentally or purposely selected so as to throw it out of balance for adequate surgical experience of the resident staff? Zollinger's[4] investigation of current trends in teaching hospitals deserves serious thought.

Artificial selection of teaching material may occur in a number of ways. The teaching hospital situated away from a large center of population is likely to have a dearth of fresh acute surgery. Since its patients must come from a distance, the simpler, but more common, as well as the acute conditions are taken care of locally and only the major elective cases reach the teaching institution. Often the diagnosis has already been made or the disease is in such advanced stage as to be self-evident and of little use for teaching purposes. University hospitals may pride themselves in the fact that they accept only cases of teaching interest and refuse to accept others. Too often I fear, no one asks the question, "Whose teaching interest, the student's, the resident's or the professor's?" Such institutions may be heavily loaded with patients representing the current research interests of the senior staff or their reputations for performing difficult but unusual operations. The teaching material is predominantly the more esoteric surgical conditions while more common, particularly traumatic cases, go elsewhere. With such artificial selection the resident may be able to perform a beautiful transthoracic gastrectomy but know little about the practical therapy of bone felon, sprained ankles, fractured ribs or the differential diagnosis of acute belly ache.

The university which has at its disposal a city or county hospital in a metropolitan center is perhaps best situated in having available a large amount of well balanced surgical material from the standpoint of age, sex and variety of usual and unusual conditions as well as a large outpatient service from which proper selection may come. The large amount of acute surgery, particularly trauma, in such hospitals is of inestimable value. Any resident who can intelligently and successfully handle a severe gunshot wound of the abdomen in the middle of the night is certainly competent to handle any major elective abdominal condition when there is plenty of time and opportunity for study, consultation, investigation and preoperative preparation. The converse is not necessarily true. The same may be said of acute conditions in other parts of the body. The usual city or county hospital does not, however, offer a cross-section of the population from the social, economic and educational standpoints. It is an inescapable fact that these factors have an effect on the type and prognosis of surgical diseases and also on the psychologic handling of the patient as well as the surgical therapy to be advised.

In the United States the Veterans Administration hospitals are in perhaps the most difficult position in regard to proper balance of clinical material. Major elective material is generally excellent but there are obvious deficiencies in outpatient, female, children, and in some cases, acute surgery. Nevertheless, this large amount of clinical material is of extreme importance to surgical education, thanks to the vision of such people as Elliott Cutler, Paul Hawley, and foremost, our own Paul Magnuson.

Firor[1] correctly states, "It is clear that the concept of a four-year graded residency is primarily the type of residency one finds in a hospital associated with a large university medical center. It is only occasionally realized in hospitals which are not connected with universities." When this statement is set opposite the statement of the Board of Surgery that there are not enough approved residencies to meet the needs of the country for qualified surgeons, a question arises which requires solution. The Board has recognized this question by continuation of approval of two years' study or practice of surgery under the supervision of a qualified surgeon following three years' residency. Such supervision is very difficult to evaluate. Often the man leaving a residency to work under a preceptor has been dropped by competitive selection from a pyramidal residency. Since he is the weak man in his group, it is he who most needs continued residency training in a teaching institution and is least able to profit from preceptorship. The best solution is to increase acceptable surgical residency facilities. Increased efforts to utilize the clinical material available in the presently non-teaching hospitals and others with borderline residency programs would go far to bring about this solution.

On the one hand we have a small number of university hospitals with excellent educational facilities necessary for surgical training but often with insufficient or poorly balanced clinical material for which the resident may assume responsibility. On the other hand there are many hospitals without necessary educational facilities but with good clinical material going to waste. With this in mind the most obvious present solution to the problem of supplying enough qualified surgeons to meet the needs of the country is combination and integration to utilize these facilities to the greatest advantage.

Affiliated or combined programs have been instituted in a few places but numerous opportunities have not been realized as they might be. Too frequently the university hospital fails to realize its own shortcomings in amount and balance of clinical material and looks down its nose at the low brow institutions which have ample material but no basic science or research program. Conversely the non-university hospital is likely to be deficient not only in the tangible but also in the intangible factors listed by Firor[1] as "(1) The professional competence and the integrity of the senior staff, and their ability and willingness to teach; (2) the responsibility given the resident; (3) the attitude of enquiry pervading the service; (4) the opportunities afforded the resident for study, investigation and teaching." The non-university institution is also frequently jealous of its successful university competitor for residents and fearful of being "taken over" with consequent loss of prestige.

When these differences between town and gown can be smoothed by a spirit of cooperation, the mutual benefits are tremendous, as demonstrated by the successful affiliation of Veterans Administration hospitals into university programs with each institution balancing the deficiencies of the other. The non-teaching hospital receives the stimulus of new thoughts and a critical evaluation of methods which raises its standards not only of education but also of patient care. Both its staff and the residents who rotate through, or are in contact with, the university service tend to develop the intangible factors cited by Firor. The university hospital is helped by more clinical material of good quality which enables it better to discharge its educational obligations to the community in training more surgeons. Its residents who rotate through the other hospital benefit by contact with many practical aspects of the art and science of surgery not found in the rarefied research atmosphere of the university.

The method and degree of rotation of residents between two or more affiliated institutions will differ according to the facilities and material available in each. Successful integration of residency programs requires thoughtful study and planning and a genuine cooperative spirit on both sides but, when attained, pays off handsomely in mutual benefit.

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EDWARD J. COUGHLIN, JR., M.D.
Williamstown, Massachusetts

SINCE World War I the medical profession as a whole and even the general public have been intensively drilled in the importance of the proper first aid management of fractures. As a result there is hardly an individual who does not know the proper application of an emergency splint for the lower extremity or the proper transportation for the fractured spine. In the past twenty years with the rapid development of fracture surgery much has been written about the management of specific fracture lesions and the various methods of fixation by means of gadgets and internal plates and rods. Unfortunately, while all of this has been going on, too little attention has been paid to the importance of recognition of some of the pathologic conditions associated with fractures and their definitive treatment. It is this subject which I have chosen to call the second aid treatment of fractures. It is not enough that we give an individual proper first aid treatment, perhaps with copious use of plasma and blood, and then neglect or overlook the many complications of nerve injuries, wide separation of fragments or the small penetrating wounds until it is too late to accomplish satisfactory functional results. As members of an association interested primarily in the treatment of trauma, it is up to us to bring the fundamental concepts of second aid treatment of fractures to the crossroads of medicine and to see that even small rural hospitals are organized for the proper management of fractures and other trauma. The complications of fractures can be more severe than the fractures themselves. I think that everyone of us has seen a fracture of the proximal phalanx of the little finger of the left hand in a right-handed individual, a relatively minor trauma. I think all of us have also seen this particular type of fracture treated with splinting on a tongue depressor for a period of three to four weeks. Perhaps the extremity may end up with partial ankylosis of the interphalangeal joints, but being the little finger of the left hand this is of very minor consequence. However, it can be catastrophic if that individual happens to be a concert violinist. The cases I am going to cite are cited not because they represent in any way any mismanagement of the case, but simply to show the importance of early recognition of certain fundamental principles and the importance of early treatment.

CASE REPORTS

CASE I. A twenty-three year old man fell from a tree while intoxicated and landed on his outstretched hand. He had immediate severe pain and deformity of his left wrist. (Fig. 1.) The patient was transported from the scene of the accident by ambulance. Because he was in a moderate degree of shock he was given a bottle of plasma en route. He had obvious deformity of the wrist. However, because of his general condition nothing was done as far as reduction was concerned for forty-eight hours at which time he was seen in consultation by a surgeon and manipulative reduction of the wrist was then carried out. Unfortunately, by that time the patient had already shown definite evidence of median nerve injury. Also, because of the extent of swelling marked impairment of the circulation of the digits developed and the cast had to be loosened with resultant loss of position. The end result was one of a marked silver-fork deformity of the wrist with definite median nerve weakness. Subsequently, excision of the distal portion of the ulna and a wedge osteotomy of the radius were required in order to restore function.

CASE II. A fifty year old woman was knocked down by a snowslide from the roof of a garage and sustained a severe twisting and adduction injury to the right knee. She was treated with emergency splinting on the scene and was transported to the hospital. X-rays revealed a depressed fracture of the medial condyle of the tibia and an avulsion fracture of the fibular head. (Fig. 2.) The patient was immobilized in plaster for a period of weeks and then

FIG. 1. Case I. Illustrates severe comminuted fracture of radius.

FIG. 2. Case II. Illustrates fracture of medial condyle with avulsion fracture of fibula head.

allowed to walk. When first seen by an orthopedic surgeon thirteen months after injury, she showed complete disruption of the external collateral ligament, a depressed fracture of the medial plateau and a complete peroneal palsy. Subsequently, she required excision of the fibular head, neurolysis of the peroneal nerve, repair of the external collateral ligament and osteotomy of the medial tibial plateau, utilizing the excised fibular head in order to restore the bony contour. At the present time, more than four years postoperatively, she has not recovered full peroneal nerve function although she now has a relatively stable knee.

CASE III. An eleven year old girl fell landing on her outstretched hand. She had immediate pain and deformity. A splint was applied and she was taken to the hospital. X-rays (Fig. 3) revealed a complete fracture of the radius and a greenstick fracture of the ulna just above the wrist joint. Reduction under anesthesia was carried out; while there was still some ulnar shift of the proximal radial fragment, it was believed that position was satisfactory. (Fig. 4.) Unfortunately, the patient was not seen for four weeks at which time x-rays revealed (Fig. 5) marked angulation and displacement of the radius, beginning evidence of crossed union and also beginning bony healing. The patient required an osteotomy of the radius and an inlay-onlay bone graft to obtain a good result. (Fig. 6.)

CASE IV. A ten year old boy fell from a tree landing on his outstretched left hand. He had immediate severe pain and deformity. A splint was applied and he was transferred to the hospital. X-rays revealed a complete fracture of both bones of the forearm approximately 2 inches above the epiphysis with overriding. Unfortunately x-rays in this case are not available. In addition it was noted that the patient had two small wounds on the volar surface of the forearm. During the period of the next four hours three unsuccessful attempts were made to reduce the fracture under anesthesia. Three days later a full blown gas bacillus infection of the arm developed, requiring radical incision and excision of large muscle groups. Subsequently, the patient had complete loss of the flexor tendons of his forearm, a portion of his median nerve, and loss of the epiphysis of both the radius and the ulna. He required repeated operations with stabilization of the wrist, suture of the median nerve and multiple tendon transplants to have even a semiserviceable wrist.

CASE V. A ten year old boy fell landing on his outstretched right hand. He had considerable pain in the arm but no deformity was noted. The patient was brought to the hospital and x-rays of the forearm were taken which revealed a greenstick fracture of the ulna in the upper third with minimal displacement. (Fig. 7.) No attempt was made at reduction and the forearm was immobilized in a

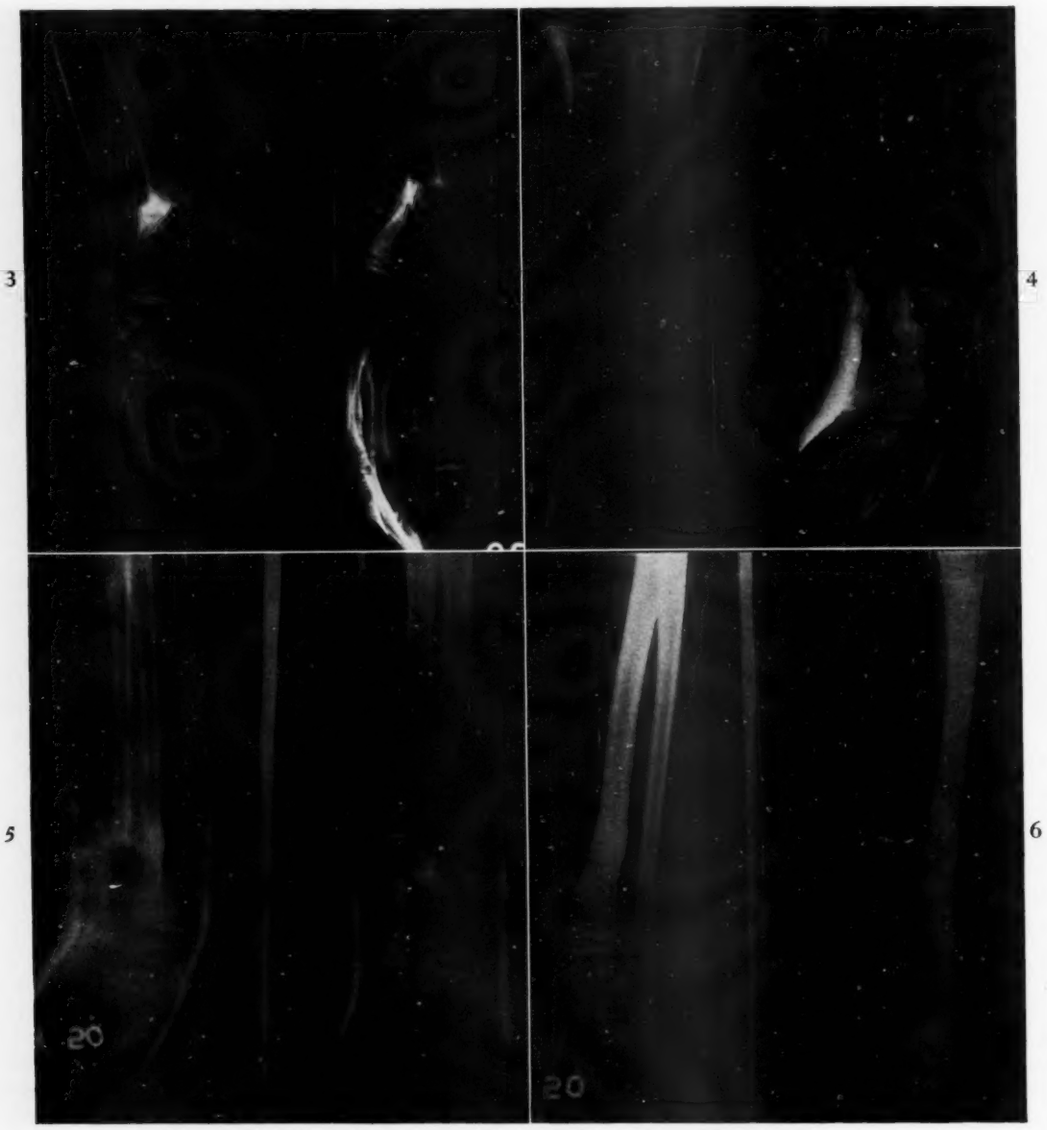

FIG. 3. Case III. Fracture of radius and ulna before reduction.
FIG. 4. Same case. Immediate postreduction.
FIG. 5. Same case. Four weeks after closed reduction.
FIG. 6. Same case. Six months after osteotomy of radius and bone graft.

plaster cast. Three weeks later it was noted that the patient was showing symptoms of radial nerve weakness. At this time x-rays were taken which included the elbow joint, and it was seen that he had increasing angulation of the ulna with displacement of the radial head. (Fig. 8.) Attempts were made to correct this and the arm was immobilized in plaster to include the elbow joint. (Fig. 9.) However, the dislocation of the radial head persisted although the radial nerve palsy rapidly cleared. It is now five years since the injury and the patient has complete function of his arm. However, the radial head is still markedly displaced both laterally and anteriorly. (Fig. 10.) This case, I believe, illustrates that mechanically one cannot have a fracture of the ulna by indirect violence without an associated lesion of the radius. Unfortunately, the original films did not include the elbow joint and the dislocation of the radial head was overlooked until it was too late to carry out any corrective procedure.

Each of the aforementioned cases represents a complication of a relatively simple fracture which was far more serious than the original fracture itself. In Case I the impairment of circulation and the median nerve weakness, secondary to the long period of delay between the original injury and the reduction, caused

Fig. 7. Case v. Original film showing greenstick fracture of ulna.
Fig. 8. Same case. Three weeks after injury showing marked displacement of radial head with increasing angulation of ulna.
Fig. 9. Same case. After attempted closed reduction.
Fig. 10. Same case. Five years after injury illustrating persistent dislocation of radial head.

severe prolonged disability. Case II represented an unrecognized complete rupture of the lateral structures of the kneejoint with probable original stretching of the peroneal nerve. In Case III complete reduction was not obtained and resultant angulation produced marked deformity. In Case IV the penetrating wound was ignored with resulting gas bacillus infection. In Case V the concomitant dislocation of the radial head was overlooked because the elbow joint was not x-rayed on the original films. The following case is presented to show that even in a small hospital good second aid treatment of fractures is possible.

Case VI. A twenty-six year old man was riding on a motorcycle which was involved in a head-on collision with an automobile. The patient was admitted to the hospital unconscious, with no blood

pressure. His injuries were as follows: compound fractures of the radius and ulna, the four metacarpal bones, four metatarsals, the femur in the middle third and the tibia and fibula, as well as separate simple fractures of the fibula higher up; traumatic amputation of the second toe; compound dislocation of the metatarsophalangeal joint of the fifth toe, a simple fracture of the left mandible and cerebral concussion.

The patient received first aid treatment in the form of splinting and copious amounts of whole blood. After several hours he was taken to the operating room where débridement and irrigation and copious lavage of all of his compound wounds were carried out. A Kirschner wire was inserted in the os calcis to treat the fractures of the tibia and femur. The traumatic amputation of the toe was completed and the wound left wide open. A simple Murray-Blake splint was applied to the left forearm with a traction hitch. The patient's general condition continued to improve after twenty-four hours and a plan of treatment was then outlined. As a preliminary procedure a modified Stader splint was applied to the left forearm although it was believed that he would certainly need internal fixation at a later date. He had some signs of median nerve injury and a banjo splint was incorporated in the Stader apparatus. At the end of twenty-one days all of the patient's wounds had healed. It was believed that definitive treatment could be instituted. Accordingly the first step on the twenty-first day after injury was open reduction of the fractured femoral shaft with internal fixation with a Küntscher nail. The patient withstood this operative procedure very well and his wound healed by primary union. Fifteen days later, or thirty-six days after injury, open reduction of both bones of the forearm was carried out. The ulna was fixed with an intramedullary nail, but the radius was not fixed except for reinforcement of the fracture with multiple iliac grafts. These were also applied around the ulnar fracture site in the form of barrel staves. This wound, likewise, healed by primary union. The fracture of the tibia, which had been immobilized at the time of internal fixation of the femoral shaft with a plaster cast, was explored on the fifty-seventh postinjury day. At that time there was no evidence of any union in the tibial fracture. This fracture was treated by means of a sliding bone graft as well as a bone plate. In addition, the graft was reinforced with multiple iliac bone chips which had been removed at the operation on the forearm twenty-one days before and had been stored in the meantime in the deep freeze. The patient is now six months postoperative. All of his fractures have healed and except for a short leg brace for his tibial fracture he is walking without support.

CONCLUSION

The complications of fractures can be a good deal more disastrous than the fracture itself, and it behooves us as members of the trauma association to educate the medical public at large on the importance of recognition of these complications and the importance of the institution of early treatment. In the severely injured individual the question of timing must be taken into consideration and basic principles applied, doing first things first and perhaps even sacrificing some anatomy to obtain a satisfactory end result.

RECENT ADVANCES IN UPPER EXTREMITY PROSTHESES*

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IT has long been apparent that a definite need existed for upper extremity prostheses which are lighter, more comfortable and possess greater versatility. However, no single clinic or manufacturer has had the material, time or funds to embark upon an investigative program of the magnitude required. It was clear that strong support and a broad program involving not only technical developments but also elements of prosthetics practice were necessary to bring the field of prosthetics to a position abreast of modern science and technology.

In 1945 the Advisory Committee on Artificial Limbs of the National Research Council and the Prosthetic and Sensory Aids Service of the Veterans Administration undertook the direction and financing of a research program dedicated to the development of improved artificial arms. Portions of this work were assigned to a number of engineering firms, limb manufacturers and research organizations. Correlation of the results and the most significant contributions to the program of research and development has been the work of the Northrop Aircraft Co., The Army Prosthetic Research Laboratory and the Department of Engineering at the University of California, Los Angeles. Concomitantly, the limb industry through the Orthopedic Appliance and Limb Manufacturers Association has acted to upgrade its standards by instituting a training and certification program for limb makers and by offering practical help and advice to the research and development program.

The results of these investigations can best be stated in terms of the prosthetic replacement that is now possible with improved devices. This is shown in Figure 1 in which the natural functions lost at each amputation site are indicated together with the available prosthetic replacement. The chart shows that it is now possible to regain all of the major motions of the arm. Although it cannot be said that these amputee motions can be accomplished with all the grace of the natural mechanism, no major action is lacking and the range of motions possible includes all that are essential to activities of everyday living.

Detailed discussion of the newer prosthetic devices can best be carried out under the general headings of (1) devices which are generally applicable, (2) the below-elbow prosthesis, (3) the above-elbow prosthesis, (4) shoulder disarticulation, (5) cineplastic applications and (6) the prosthetics team necessary to conduct the quality of amputee service consistant with the new technology.

NEW DEVICES WHICH ARE GENERALLY APPLICABLE

Those newer products which are suitable to all upper extremity prosthetics will be considered as follows:

New Terminal Devices. An ideal terminal device from the standpoint of function and appearance is necessarily limited by several practical factors. If it is too heavy, the fatigue occasioned by its use nullifies its usefulness. If its construction is too complicated or not sufficiently strong, frequent breaking down destroys its utility. If its control is too complex, it cannot be functional. It must not be too expensive.

The need for three types of terminal devices of improved design and function has been paramount. These were a voluntary opening hook, a voluntary closing hook and a voluntary closing hand.

Voluntary opening hook: An eminently satisfactory voluntary opening hook has been developed by the Northrop Aircraft Co. which, operating against a spring, provides

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selective tip forces of either 4 or 8 pounds. (Fig. 2.) This spring closure is analogous to the rubber band closing force used in the majority of conventional hooks. Opening is carried out by active operation of the shoulder harness or cineplastic tunnel. The voluntary opening hook is particularly advantageous to the bilateral amputee. It is simple mechanically and no braking or clutch mechanism is necessary. Thus the new hook not only extends the range of grasp force but also eliminates the rubber bands which have always been a source of annoyance to the amputee.

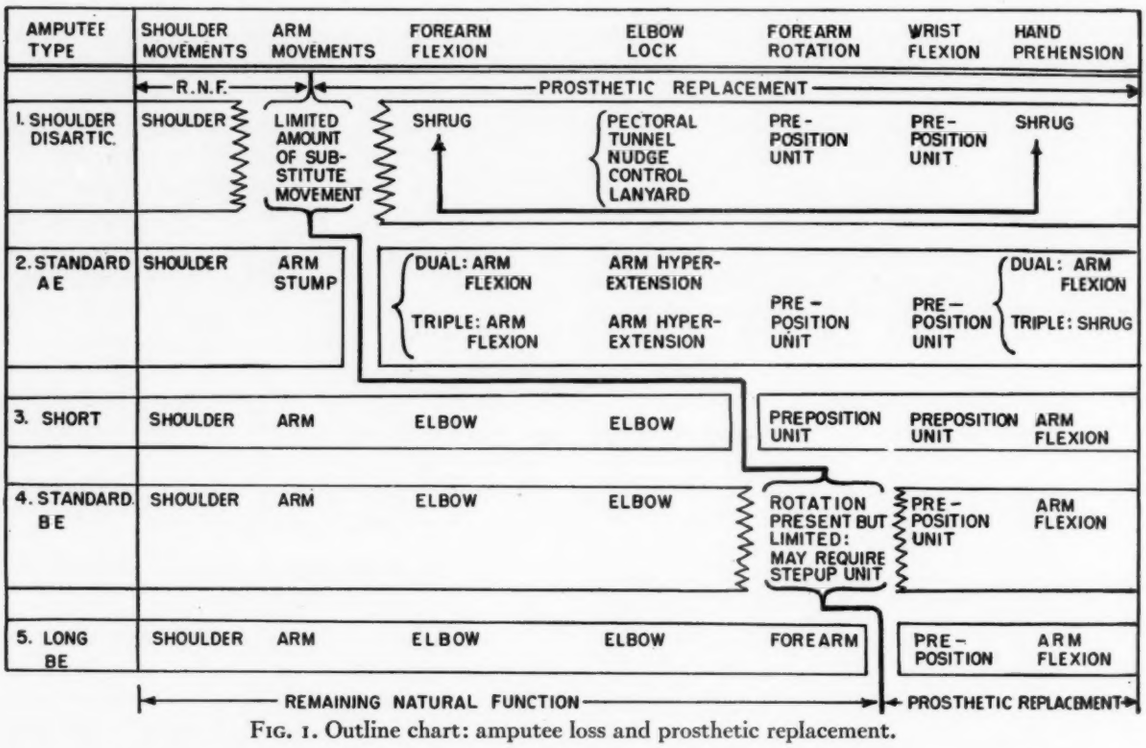

FIG. 1. Outline chart: amputee loss and prosthetic replacement.

Voluntary closing hook: This hook is operated by muscle force and opened by a spring. A satisfactory hook of this type has been designed by the Army Prosthetic Research Laboratory. This hook, shown in Figure 3, provides graduated prehension up to 25 pounds. This involves a more complicated mechanism than the voluntary opening hook in that a controlled clutching device is necessary. Its activation and control by the amputee is therefore more complicated. The user of this hook is enabled to pinch gently or forceably as the closing mechanism is activated. The hook fingers lock automatically when the closing force ceases. An added motion on the part of the wearer is therefore necessary to release the lock when he wishes to let go. Because this additional motion is necessary to disengage the lock, many amputees prefer the voluntary opening hook. Precision mechanical workers who desire strength and the ability to grade prehension find the voluntary closing hook superior to the voluntary opening type.

Both voluntary opening and voluntary closing hooks are now of lyre-shaped design; the grasping surface of the fingers is rubber tipped while the outer surface is smooth. The fingers are interchangeable for right or left hands and for either type hook.

Voluntary closing hand: The APRL voluntary closing hand is a much improved mechanism over the older types. It meets the specifications of strength, lightness, durability, simplicity of mechanism, and control, mechanical efficiency, graded prehension and cosmetic appearance. (Fig. 4.) The digits, when in the resting position, approximate the resting position of the normal hand. The two-position stable thumb may be widely opened to permit grasp of objects between 1½ and 3 inches in diameter or positioned to permit grasping objects 1½ inches or less in diameter. The index and middle fingers oppose the thumb in palmar

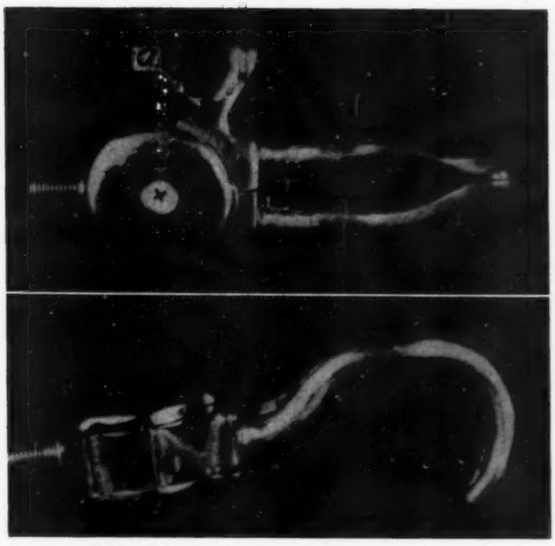

FIG. 2. The Northrop two-load voluntary opening hook. Front view shows operating thumb with load shift selector (*a*). The lyre-shaped hook fingers are rubber lined on gripping surfaces. The side view shows stylized curve of hook fingers.

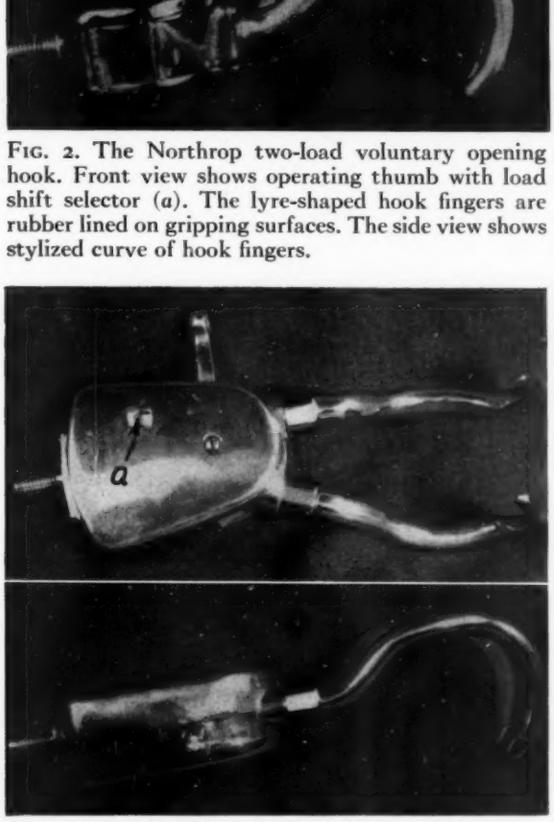

FIG. 3. The APRL voluntary closing hook. Front view shows operating thumb and hook-opening selector (*a*). At "full" the hooks open to 3 inches; at "half" they are limited to 1.5 inches. Hooks are rubber lined to improve gripping surfaces.

prehension at the same angle as the normal hand. Motion occurs at the metacarpal-phalangeal joint only. The palmar surfaces of the digits are padded, and this together with a covering plastic glove offers a resilient surface which approaches the natural finger pads in effectiveness of grasp. The ring and small fingers are flexible and passive to prevent

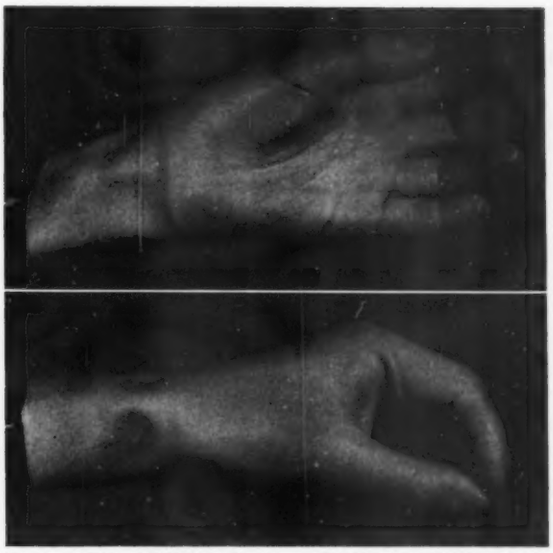

FIG. 4. The APRL voluntary closing hand. The side view displays the characteristic palmar prehension pattern. The palmar view shows resting thumb and finger attitudes. Digits 2 and 3 oppose the thumb in prehension; digits 4 and 5 are semi-flexible and passive in action.

interference with action of the three grasping digits. A mechanism similar to that used in the APRL hook, which enables the amputee to maintain the grasp without continuous effort, is incorporated. This device is automatically activated when the closing pull of the cable ceases. To release the object the lock is disengaged by a pull on the control equal to the original closing pull.

The hand is covered by a tough, stain and abrasion resistant, and flexible plastic glove. This can be treated to match the color, hair distribution and creases of the individual's normal hand and thus attains a cosmetic appearance which obviates considerable embarrassment in the amputee who is sensitive about his loss. These hands are being more widely accepted by amputees than was anticipated because they are not only esthetic but perform well most daily tasks. For heavy manual work the greater strength and durability of the hook makes it still the device of choice. A universal wrist disconnect makes the hooks and hand interchangeable.

Wrist Flexion Unit. The wrist flexion unit mechanically simulates the natural volar flexion at the wrist. It can be preset by a manual selector at 25 or 50 degrees of volar flexion, bringing the hand or hook into favorable position for manipulations close to the body.

Bowden Cable Control. The conventional rawhide control strap or wire has been replaced by the Bowden cable, adapted from the airplane, complete with its enclosed housing and swivel mounts. It is strong and tough. Its great usefulness derives from the fact that its length remains constant in every position of the prosthesis so that the force delivered is always constant and approximately equal to that expended in the pull. Thus the hand or hook can be operated at all important positions of use independently of arm angles. The applications of this control together with accessory controls are shown in Table 1.

TABLE 1
PROSTHETIC CONTROLS

Function		Forearm Flexion	Prehension
Amputee Type	Elbow Lock		
BE amputee:	.....	Natural	Arm flexion
AE amputee: Dual	Arm extension	Arm flexion*	Arm flexion*
Triple	Arm extension	Arm flexion	Shoulder shrug

* Depending upon position of the elbow lock this control motion produces forearm flexion or prehension.

NEW MATERIALS

Several improved materials are used in the construction of the upper extremity prosthesis. A nylon coating for leather has been developed which, by impregnating and covering the individual fibers, renders the material waterproof, sweat resisting, longer lived yet still pliable and non-irritating to the skin. The absorption of sweat by untreated leather has caused it to be used sparingly in prostheses recently. This new plastic coating gives promise of permitting a reversal of this tendency, with increased use of leather for shoulder saddles, arm cuffs and harness parts. Thermosetting, laminated plastic is now used almost exclusively in constructing the socket. This material is light, strong, durable and easy to form to contours of the individual stump.

Aluminum is employed in the construction of joint straps, elbow units, wrist units, hooks and hands, except for those small parts which receive excessive wear of stresses. These are necessarily made of steel. Magnesium shows promise of still further weight reduction.

The adoption of new textile materials for harness construction has aided function, comfort and personal hygiene. Nylon and vinyon strap materials combine the advantages of high tensile strength, launderability, easy adjustability, lightness and freedom from irritation.

Below-elbow Prosthesis. These are classified according to type, as follows: (1) long (including wrist disarticulation), (2) mid-arm (ideal) and (3) short (3-inches below elbow). The essential components of the BE prosthesis are shown in Figure 5. They include the socket, socket suspension, control harness, wrist unit and terminal device. The length and in some instances the type of socket and suspension vary with the length of the BE stump, but the BE harness universally consists of a figure eight with a loop over the opposite shoulder.

Long below-elbow stump: Here the flexible elbow hinge may often be used with straps affixing the socket to a cuff piece on the arm. (Fig. 5.) The harness in most instances is the figure eight with a simple loop about the opposite shoulder. Passing over the front of the shoulder is a suspensory strap to the arm cuff; over the back is the harness strap to the Bowden cable control. A forward swing of the humerus produces the relative displacement in the Bowden cable which operates the terminal device.

Forearm rotation is usually retained in a long below-elbow stump so that no mechanical rotation mechanism is needed.

Mid-arm stump: The problem of fitting the mid-arm below-elbow stump differs from that of the long below-elbow stump in that a significant degree of rotation may be lost. If the residual is greater than 90 degrees, the single socket previously described may be used; but if it is less than 90 degrees, augmentation of the rotation is desirable. For this purpose a step-up rotation unit has been devised. (Fig. 6.) This consists of inner and outer sockets geared to each other. The inner socket fits the lower end of the stump snugly and rotates with it. The outer socket (forearm section) extends, and is attached to, a flexible elbow hinge which permits free rotation of the inner socket. The system of gears amplifies rotation of the terminal device in a ratio of 2.3 to 1.

Short below-elbow stump: In this type of stump there may be marked restriction of elbow motion. To increase the effective range of elbow motion a socket and geared elbow

joint are available. (Fig. 7.) The socket fits the stump snugly while the terminal device is attached to the forearm section (outer socket). When the elbow is flexed, the gears activate the forearm section through an arc two times as great as that of the socket. No prehension in the terminal device, depending upon the setting of the elbow lock. A locked elbow causes this control to activate the hook; an unlocked elbow applies the control force to forearm flexion. The triple system necessitates two controls from the back and shoulders.

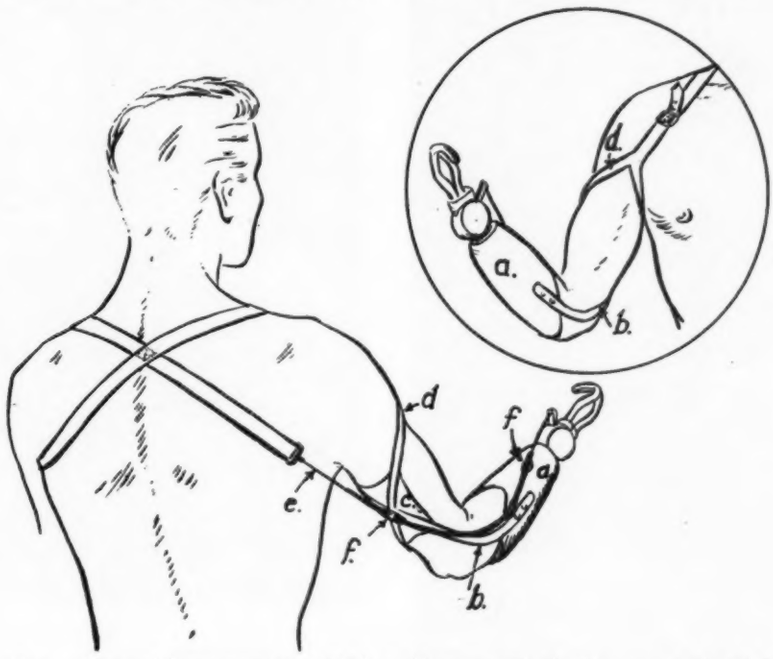

FIG. 5. Essential components of below-elbow prosthesis. Forearm socket (*a*) is stabilized by strap (*b*) which also serves as a flexible hinge to leather cuff (*c*) on the arm. The control cable (*e*) runs from hook thumb through cable retainers (*f, f*) to shoulder harness. Strap (*e*) also suspends the arm cuff to shoulder harness.

forearm rotation is permitted by this rigid hinge system.

Above-elbow Prostbesis. The components of this prosthesis as displayed in Figure 8 are the arm socket, the elbow unit, the forearm section, wrist unit, terminal device, and the harness and control system. The fitted plastic socket is carried up to the axilla on the medial side but higher on the lateral side.

Two improved types of elbow units are available. Both incorporate shoulder-operated locking mechanisms in selected or innumerable positions. It is standard practice for this to be activated by extending the arm backward with the shoulder held fixed. An alternating lock-unlock mechanism is utilized so that the same motion performs either function.

The AE control systems, as indicated in Table 1, may either be dual or triple. In the dual system the arm flexion motion may be utilized to accomplish forearm flexion or One of these, the prehension control, is operated by a shoulder shrug (scapular abduction); another, the forearm flexion control, is operated by arm flexion. As in the dual system, elbow lock is activated by the arm extension.

Shoulder Disarticulation Prostbesis (Including 2 Inches or Less of Humerus). The components of this type of prosthesis are the same as for the above-elbow stump except that the socket is extended up onto the shoulder in cap form approximately two-thirds of the distance from acromium to base of neck. An inner close-fitting socket which stabilizes the apparatus is covered by an outer shell which restores normal shoulder contour. A chest strap is necessary to maintain fixation of the prosthesis on the thorax. The elbow lock must be operated manually, by nudge control, or by shoulder girdle elevation, since no downward thrust of the prosthesis away from the shoulder is possible. As shown in Figure 9,

FIG. 6. Rotation forearm for below-elbow amputees. Inner socket (*a*) rotates with pronation or supination of forearm. This rotation is amplified 2.3 to 1 as it operates the hook. Outer socket (*b*) holds rotation bearing and gearing and is in turn hinged to arm cuff (*c*).

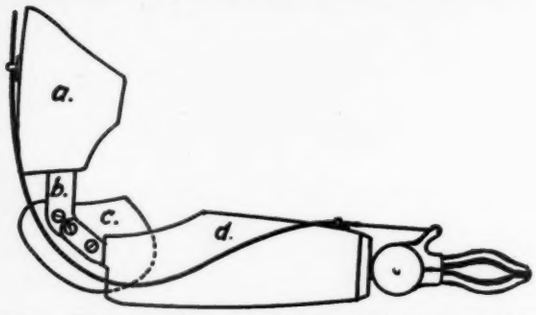

FIG. 7. Step-up elbow arm for short BE stumps. Arm cuff (*a*) serves as attachment for special hinge joints (*b*) upon which BE socket (*c*) and forearm section (*d*) pivot. Flexion of (*c*) is transmitted through the special hinge gearing to (*d*) which flexes at twice the range of (*c*).

a high back-shrug control is used to flex the forearm or operate the terminal device, depending upon elbow lock setting, i.e., dual control.

Cineplastic Prostbesis. Research on the cineplasty application is proceeding on many fronts. At present only the biceps tunnel for the BE amputee can be said to be out of the experimental phase. The features of this application are shown in Figure 10. The pin through the tunnel is connected to hook or hand by the same type of cable used in the conventional prosthesis. It has been found that with the larger muscle tunnels now being fashioned a stainless steel pin ⅜ to ½ inch in diameter is desirable. A slight curve of the pin makes it self-centering. The necessity for shoulder suspension and a control operated by shoulder shrug is eliminated because the

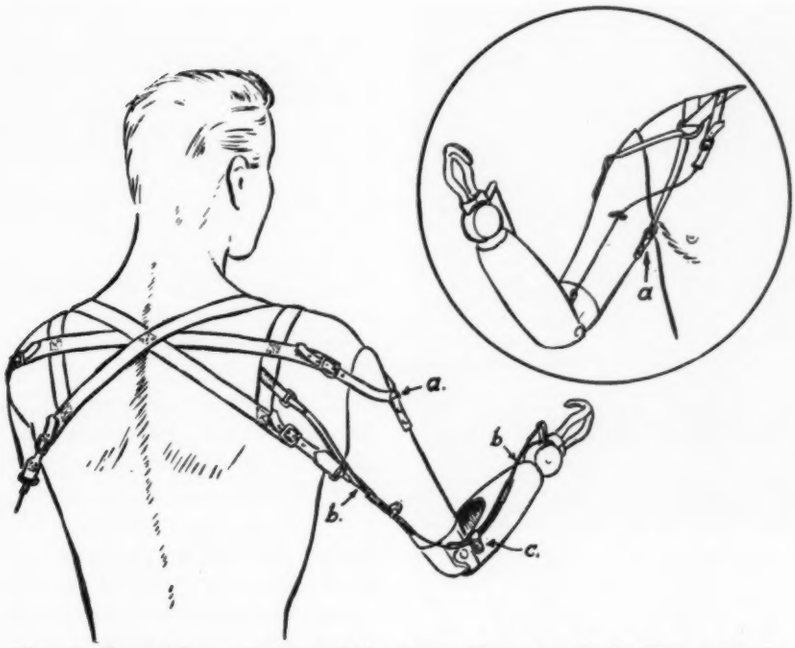

FIG. 8. Essential components of the above-elbow prosthesis. The socket is suspended by straps through D-rings (*a*, *a*). Control cable (*b*, *b*) runs from back harness through forearm lift loop (*c*) to connect with hook operating thumb. Insert shows the elbow lock cord operating from front of shoulder harness. The loop at (*c*) causes control cable force to flex forearm when elbow is unlocked.

FIG. 9. Shoulder disarticulation prosthesis. The integral arm and shoulder cap are stabilized to the torso by a cross chest strap. Back view shows the control strap and cable to forearm flexion and hook operation. The elbow lock is operated by a pectoral tunnel, as shown in front view.

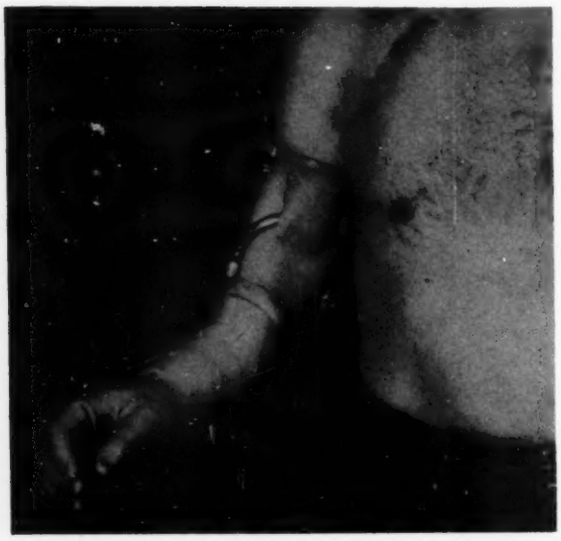

FIG. 10. Biceps cineplastic tunnel for below-elbow amputee. The curved muscle pin attaches to pull cable on medial aspect of elbow. This cable, coursing through the prosthetic forearm, operates the prehension mechanism of the APRL hand. Note absence of all harness above mid-arm.

muscle tunnel provides a considerable amount of suspension and stability. The BE biceps cineplasty prosthesis rivals the conventional BE prosthesis in power of grasp. It is clearly superior in the convenience and comfort permitted by elimination of shoulder harness and in the precision and sensitivity of terminal device operation, some deep muscle sense being regained through the muscle tunnel.

Prosthetic Team. The surgeon's responsibility does not end when the operative wound is healed. Conditioning of the stump, restoration of function in the remaining muscles and joints, psychologic acceptance of his handicap by the patient, the prescription of the prosthesis best adapted to the needs of the patient and training in its use are his duty. These obligations necessitate the cooperative action of the prosthetic team, i.e., physical therapist, psychologist, prosthetist, amputee trainer and job councellor. Each has an important and interdependent role in the rehabilitation of the amputee. The prescription of the prosthesis, however, is the privilege of the surgeon. It cannot be left to the prosthetist. Knowledge of the various types of prostheses, their performance standards and limitations, and their adaptability to the type of amputation and type of amputee is an essential part of his armamentarium.

Note: Technical information relative to the devices described in this paper may be obtained from the office of the Executive Director, Advisory Committee on Artificial Limbs, National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D. C.

OPERATIVE TREATMENT OF T AND Y FRACTURES OF THE LOWER END OF THE HUMERUS

WILLIAM H. CASSEBAUM, M.D.
New York, New York

T and Y fractures of the lower end of the humerus result from severe trauma to the elbow. Conservative methods of treatment have rarely given good results. To fix the fragments by transfixation pins involves dangers to nerves and vessels, does not modify the difficulties of closed reduction and does not provide secure fixation. In our hands best results have resulted from open reduction and fixation with screws.

Because of the anatomic difficulties which are increased by the comminution of fragments, perfect reduction and perfect immobilization cannot always be obtained. We, therefore, list the principle objects of open reduction in the order of their importance.

(1) The essential relationship to be re-established is that of the condyles to each other and to the ulna. The fracture line into the joint usually goes through the lateral portion of the trochlea; and if there is rotation of the fragments or separation of the fragments, movement of the ulna bone will be restricted. Not infrequently this surface of the trochlea is comminuted and one or two small fragments may be split off. A complete surface is not as essential as anatomic position of the main condylar fragments. Fortunately the main fragments always have some matching surfaces so that perfect refitting is possible. The smaller comminuted fragments can then be discarded or they may be retained if there is no danger of their becoming displaced from their bed. We have found a screw placed transversely through the condyles from the lateral to the medial side gives secure immobilization.

Good results with something less than perfect anatomic restitution are possible.

(2) The next most important objective of the operative procedure is to keep the olecranon fossa open and of adequate size to admit the olecranon. Imperfect reduction or excessive callus from exposed raw bony surfaces will prevent extension of the elbow and adhesions between callus and muscle and tendon may restrict flexion.

(3) Perhaps just as important for return of function is preservation or re-establishment of the forward tilt of the articular surface of the condyle. The angle made by the condyles to the shaft in the lateral view is considerable; and if this is lost, flexion will be limited and the hand may have difficulty reaching the mouth and head.

(4) Once the joint surfaces are in anatomic relation and the olecranon fossa made adequate, fixation of the condyles to the shaft is accomplished. How this is done will vary with the type of fracture. Frequently either the medial or lateral fragment is a large one with a vertical fracture line. At other times there is further comminution of these large fragments and consequently greater difficulty is encountered in fixing them to the shaft.

(5) Secure fixation is important in order to minimize the amount of callus that is formed. It permits early active motion without pain. The latter is essential to a good early result but not as important in the end result. Most of our cases have been fixed securely enough so that after a week the patient was able to start flexing and extending the elbow while in balanced suspension. This motion and elevation help rid the part of edema and prevents fibrosis. We believe that persistence of an exudate excites fibroblasts to proliferate with resultant thickening and shortening of ligaments.

Muscle action increases the circulation of blood and lymph and speeds the removal of damaged tissue and exudates. This activity during bone healing also preserves muscle strength which is so essential to moving and controlling a joint.

The damage resulting from the posterior operative approach does not seem to be significant. Much of the posterior synovia can be removed and yet good motion will be re-established.

OPERATION TECHNIC

With the patient in the prone position and a dry field provided by a Campbell pneumatic

tourniquet and an Esmarch bandage, a long incision is made on the back of the lower arm and forearm—a short transverse step being made at the point of the elbow. The skin is dissected from the fascia and the ulner nerve is exposed and retracted with tape. Then the triceps muscle is dissected down to the bone and the ulna bone divided through the sigmoid fossa with a sharp osteotome. This is retracted upward exposing the fracture. Any adherent muscle is raised with a periosteal elevator. The condylar fragments are then reduced and held with a towel clip, one tooth imbedding in the cortex of the medial side of the trochlea and the other imbedding on the lateral side of the capitellum. A drill hole is then made from the lateral epicondyle through the capitellum and trochlea. The wood screw inserted through this must be accurately placed so as not to enter the joint. Care must be taken that it enters the second fragment without resistance otherwise there is a tendency for the fragments to separate. Once this screw is placed the two fragments are fixed and firm and will remain so when the joint is moved. The number and direction of other screws used to fix the fragments will, of course, vary with the situation. One must be familiar with the shape of the normal bone in this area in order to work out placements which will secure good cortex for the screws to bite into and yet not cross the paths of others. It is sometimes difficult, but usually the immobilization obtained is sufficient to permit the patient's arm to be in suspension without external fixation.

The ulna is repaired with a screw. This holds it so solidly that immediate motion is possible. Occasionally it may be necessary to transplant the ulner nerve. After closure of the wound a cast is applied to protect the arm while the patient recovers from anaesthesia and sometimes for a few days thereafter. Most often, once the patient is awake he is just as comfortable in suspension with adhesive traction on the forearm. The counter-balancing weight permits active motion with an even resistance that minimizes pain. After the elbow becomes painless and motion increases the patient is anxious to get out of bed; and while remaining supine until union occurs might make for better and earlier elbow function, the patients just will not remain that long.

CASE REPORTS

Case I. C. U., a twenty-four year old girl, fell while roller skating. Closed reduction failed and the patient was operated on twelve days after injury. Although fracture exposure was limited by dividing only the lateral half of the triceps, a good reduction was obtained. The arm and elbow were swollen and beefy at the time so that considerable bloody ooze occurred and the patient was shocked after two hours operating. Very limited active motion was begun at three weeks and splints were discarded at five weeks. The patient made a good recovery and was followed up for five years. When last seen she worked as a waitress and had full supination and pronation, extension 165, flexion to 35 degrees. An excellent result.

Case II. Lt. H. P., a French officer, injured in a jeep accident was treated at the Ninth Evacuation Hospital (Roosevelt Unit) in Naples, Italy. The arm was suspended for ten days because of marked swelling. Operated on in late March, 1944, his cast was removed eight days later and active motion in suspension begun. By mid-April the patient had the following range of motion: supination 0, pronation 45 degrees, extension 150 degrees and flexion to 100 degrees.

In a letter from North Africa May 20, 1944, measurements by a French surgeon stated he had 165 degrees extension, flexion to 50 degrees, normal pronation and supination, and a normal scar.

Although the period of observation was short, this man gave every indication of having an excellent result and is so classified.

Case III. M. M. fell in the street on January 2, 1948. Forty eight hours later her T fracture of the elbow was operated upon through a posterior incision. A closed reduction had been attempted and failed. A Colles fracture on the same side had been reduced and splints applied to it. At operation fixation of the large lateral condylar fragment was obtained by application of a four-screw plate. The medial epicondylar fragment was fixed by a single long screw attaching it to the shaft of the humerus. The patient was discharged from the hospital on her fourteenth postoperative day, wearing a plaster cast. This was removed five weeks postoperatively. At the end of eight months she had flexion to 80 degrees, extension 165, but lacked 45 degrees of supination. Now, three and a half years after operation, she has 182 degrees extension, flexion to 45 degrees. She lacks 10 degrees of supination and 30 to 35 degrees of pronation. She works as a telephone operator. The patient suffers from mild cardiac failure and angina. In our opinion the restriction of pronation and supination is due to deformity from the Colles fracture and not from her elbow injury.

Case IV. E. W., a sixty-five year old woman,

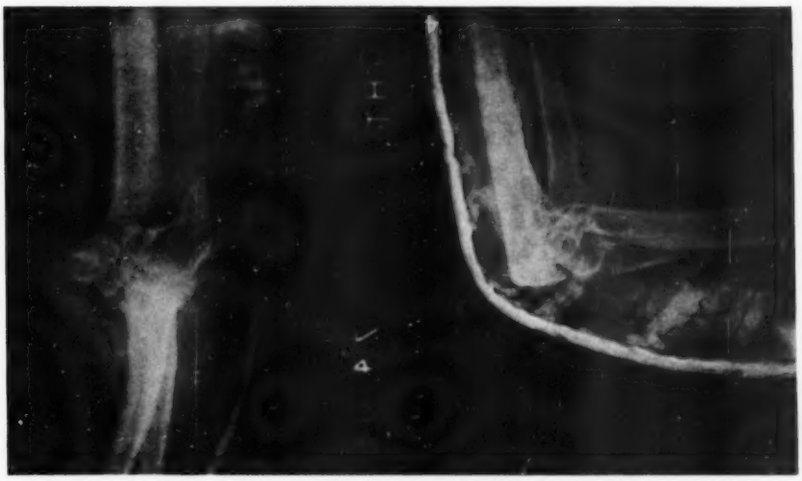

FIG. 1. Case v, after attempted closed reduction.

injured her elbow by a fall on an icy street two weeks before admission, January 5, 1949. The elbows had been treated in a cast but the anatomic result was poor. Seventeen days after injury the elbow was operated upon through a posterior incision dividing the olecranon and retracting it and the triceps tendon upward. The fractures were reduced and fixed by screws. Three days postoperatively the patient was placed in suspension for exercise.

In repairing the ulna the screw was directed laterally and forward so that it interfered with supination of the radius. This interference was increased by the formation of callus around the protruding portion of the screw causing further limitation.

Now two years and ten months after operation, the patient has extension to 160 degrees, flexion to 60 degrees and 80 degrees of pronation and supination (60 degrees pronation from mid-position and 20 degrees supination). Until September, 1951, she rejected the idea of removing the offending screw to increase her motion. This has now been done and the callus removed too, though we doubt that the result will be changed appreciably. She occasionally has pain during changes of weather. This result is classed as fair. The reason for this was a technical error and not the fault of the method.

CASE V. C. R., a fifty-seven year old woman, fell in May, 1950. Her fracture could not be reduced or maintained in plaster. Five days after injury an open operation was performed and excellent anatomic restitution obtained. The fixation felt secure. Four days postoperatively the patient was placed in suspension by skin traction. Two weeks postoperatively she was out of bed and using only a sling for support. (Fig. 1.)

The anatomic and functional result at the elbow is excellent. Pronation and supination are complete. The patient lacks only a few degrees of extension. This motion was attained within five months after operation. (Figs 2 and 3.)

FIG. 2. Case v, x-ray fifteen months after operation.

The patient has, however, had a complication involving her hand probably due to ulna nerve irritation though we cannot determine why. The middle and ring fingers of this hand are hyperextended at the proximal interphalangeal joints and slightly flexed at the distal finger joints. Closure of the first is not quite complete although her grip is good. The hand feels slightly colder than the other one. Radial pulses are equal. It is not known whether or not the ulna nerve injury existed before operation.

Her elbow is almost perfect but this nerve complication reduces her rating to good.

CASE VI. A. C., a sixty-four year old woman, fell and received a compound intercondylar T fracture on February 22, 1950. The compound wound was of pin-point size. She was operated upon immediately and two plates and eight screws used to maintain the reduction. The patient is a

FIG. 3. Case v, elbow flexion (right arm.)

FIG. 4. Case vii, anteroposterior views preoperatively.

placid woman and occupied a bed for thirty-nine days, much to the consternation of the resident staff. During this time she exercised well in suspension; but when it was removed, her range of motion was reduced. After going home she did not exercise effectively.

Now, one year and seven months later, the functional result is classed as good. Her range of motion is flexion to 80 degrees, extension 145, pronation 80 degrees, supination 80 degrees. She has good strength and is free of pain.

CASE VII. D. B. was knocked down by wind as she made her exit from a subway station on November 23, 1950. At the same time she received a severe V fracture to her right elbow, suffered a compression fracture of the right tarsal navicular and an impacted fracture of the neck of the right femur. (Fig. 4.)

The elbow was operated on the same evening through a posterior incision, the olecranon being divided and retracted. A good anatomic reduction was obtained. After a few days she began exercises in suspension. The patient reported a clicking as she flexed and extended the elbow and x-rays suggested there might be some shifting of the epicondylar and shaft fragments but no change in the essential relationship of the two condyles. A plaster arm cast was applied but the clicking continued five weeks postoperatively. At that time she was readmitted to the hospital for a week in suspension. On her return home her husband rigged up an ingenious suspension frame for her to use in exercising. This she did vigorously. Functional recovery was speedy and she now has an excellent anatomic and functional result in which her own determination was a factor. Motion is practically complete. (Figs. 5 and 6.)

CASE VIII. M. S., a forty-four year old man, fractured his right elbow and wrist on January 2, 1951. Conservative attempts to reduce the fracture were made at another hospital. He entered Roosevelt Hospital on January 6th and was operated upon January 9th after three days of elevated suspension. The posterior incision dividing the olecranon process and reflecting the triceps was used. The fixation of the humeral fracture obtained with three screws was very secure. His ulna nerve was transplanted anteriorly. Six days postoperatively a Kirschner wire was placed through the metacarpals and suspension exercises began. The wire through the metacarpals proved painful and skin traction suspension was substituted. He did well in this but insisted on going home on his fourteen postoperative day. At this time his range of motion was 80 to 135 degrees.

No change was made in the Colles fracture. The patient had also suffered from a bleeding peptic ulcer during his hospitalization.

Following discharge he never exercised vigorously, complaining of pain in the wrist and hand. Considerable atrophy of his forearm muscles developed.

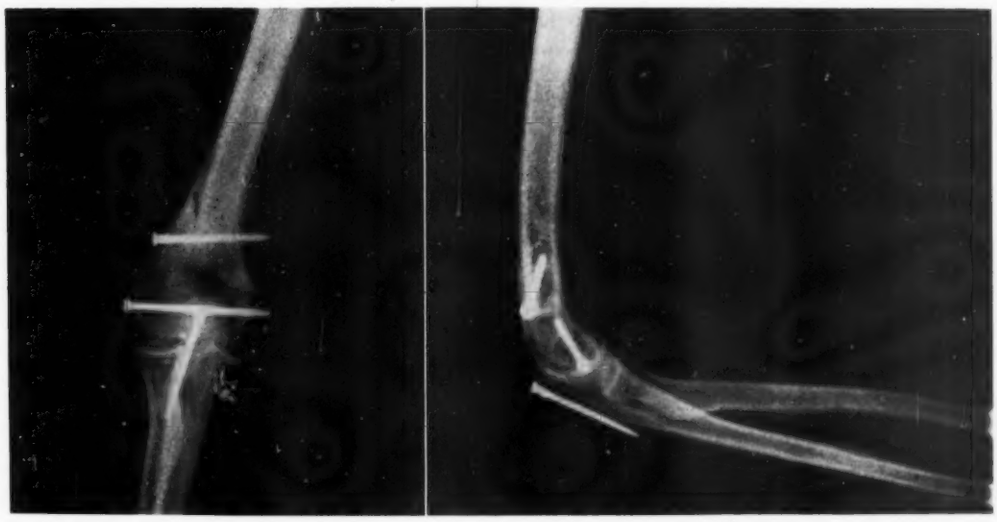

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FIG. 5. Case VII, postoperative anteroposterior views at three months.
FIG. 6. Case VII, postoperative lateral view at three months.

When last seen on August 17, 1951, he was free of pain and could reach his mouth and shave. His range of motion was flexion to 80, extension 135, pronation 35 degrees, supination 35 degrees.

Check-up x-rays showed that we had not re-established the normal forward angle of the trochlea and capitellum with the shaft and his difficulty with flexion is mostly due to this. The gross anatomic appearance is excellent. The patient has not yet reached an end result, but even now it is good.

CASE IX. K. R., a fifty-nine year old patient, was operated upon by Dr. Adrian Lambert who employed the same method, using the posterior olecranon-dividing incision. This patient suffered from rheumatoid arthritis and was receiving 50 mg. of cortisone daily at the time she fell on February 8, 1951. Two days later she was operated

TABLE I

SUMMARY

Patient	Age	A*	B	Method of Fixation	Extension	Flexion to	Pronation	Supination	Follow-up	Classification of Result†
C. U.	24	12	35	2 screws	165°	35°	full	full	6 yr.	E
Lt. H. P.	30	10	8‡	3 screws	165°	50°	full	full	2 mo.	E
M. M. (1)	66	2	35	1 plate 1 screw	180°	45°	lacks 30°–35°	lacks 10°	3½ yr.	G
E. W. (2)	65	17	3‡	2 screws	160°	60°	60°	20°	2 yr. 10 mo.	F
C. R. (3)	57	5	4‡	4 screws	175°	40°	full	full	1 yr. 4 mo.	G
A. C.	65	0	2‡	2 plates	145°	80°	80°	80°	1 yr. 7 mo.	G
D. B.	48	0	1‡	2 screws	180°	40°	full	full	10 mo.	E
M. S. (4)	44	7	6‡	3 screws	135°	80°	35°	35°	7½ mo.	G
E. R. (5)	59	2	4	2 screws	140°	50°	full	full	7 mo.	E

Remarks:
(1) Pronation-supination limitation attributed to Colles fracture deformity.
(2) Pronation-supination interfered with by screw fixing the ulna.
(3) Complication in hand due to ulna nerve injury?—some discomfort.
(4) Colles fracture deformity limited pronation—supination.
(5) Patient taking 50 mg. cortisone daily for atrophic arthritis.
* A = days between injury and operation; B = days between operation and first active motion.
† E = excellent; G = good; F = fair.
‡ Active motion in suspension.

upon and fixed with two screws. After the four postoperative day her cast was removed for daily exercise and eleven days postoperatively she had motion from 135 to 80 degrees. It was believed that cortisone therapy delayed wound healing as part of the skin wound separated somewhat when the sutures were removed on the tenth day. The remaining sutures were left eighteen days.

On October 4, 1951, (eight months later) she had 140 degrees extension, flexion to 50 degrees and no limitation of pronation or supination. X-rays show narrowing of the joint space. Her hands and feet show the typical deformities of severe arthritis. She has no pain and is well pleased.

COMMENTS

Of the nine cases reported, four are classified as excellent results, four as good and one fair. The patient who had a fair result might easily have had an excellent one but for an avoidable technical error. Case VI had an excellent result at the elbow but nerve irritation caused difficulty in the hand. Cases III and VIII had associated Colles fractures. In case III the deformity of the Colles fracture caused limitation of pronation-supination movement. In case VIII it seemed that discomfort properly attributed to the Colles fracture restricted muscular activity of the extremity. (Table I.)

Based on this experience we believe that satisfactory results can be obtained by open reduction and fixation. An adequate incision is of paramount importance if one is to achieve the objectives of the operation. The earlier the operation is done the better the results will be and the swifter the recovery. Van Gorder in 1940 believed that a try at closed reduction was indicated but this adds trauma and delays operation past the optimum time. Once the operation is complete active motion in suspension is possible in most cases. This is a great aid in obtaining a good early result but is not as important in the final result. Improvement occurs over at least two years. In all cases the gross anatomic appearance has been excellent and scars on the back of the elbow are rarely perceptible. The functional results have far exceeded those obtained by any other method. While nine cases is too small a number in which to develop a perfected technic, the author is convinced that reflecting the olecranon through an adequate posterior incision has made the procedure relatively easy.

SUMMARY

An operative method for open reduction and internal fixation of T and Y fractures of the lower end of the humerus is described.

The principals, objectives and technic of the operative are discussed. Nine illustrative cases are cited and the results recorded.

AN ELBOW AND AN ELBOW PROSTHESIS

CASE OF COMPLETE LOSS OF THE LOWER THIRD OF THE HUMERUS

CHARLES S. VENABLE

San Antonio, Texas

YOU may wonder why anyone would undertake to make an artificial elbow for a patient who had previously lost a hand, but I hope when I place before you what was done and the reasons why you may lend me your understanding of my effort in an attempted reparation.

This patient, E. E., who had lost his right hand at the wrist several years ago, had developed his musical abilities and had become a violinist and orchestra leader using an artificial hand to control his bow or baton.

The patient was injured when he slipped and fell in a shower bath. Having no hand to catch himself, he struck directly on his elbow and literally shattered the distal end of the humerus. The olecranon process was not fractured but had acted as a wedge driven upward between the condyles and splitting them apart with total destruction of the olecranon fossa while the combating force from above downward splintered and crushed the lower fifth of the humerus into fragments of many shapes and sizes. (Fig. 1.)

Thus the problem presented, as you have now seen it, was not only one of clinical repair but also demanded the consideration of the patient's means of livelihood. I know of no more fitting place to submit it for discussion and opinion than before this Association created in the interest of Trauma and improved efforts of repair.

In my opinion these multiple fragments could have been aligned to adjacency with an expectancy of bone union with the elbow ultimately fixed at 90 degrees of flexion, which is probably what I would have done had it not been so important for this man to have sufficient function in flexion and extension as well as continued pronation and supination of the forearm to carry on as a musical conductor.

It seemed to me that the only way to attain this was in some manner to re-establish the original length and articular factor of the lower end of the humerus by replacement of that which was lost and develop an arrangement over which the olecranon process, with its coronoid fossa, could articulate and so retain the function of the forearm.

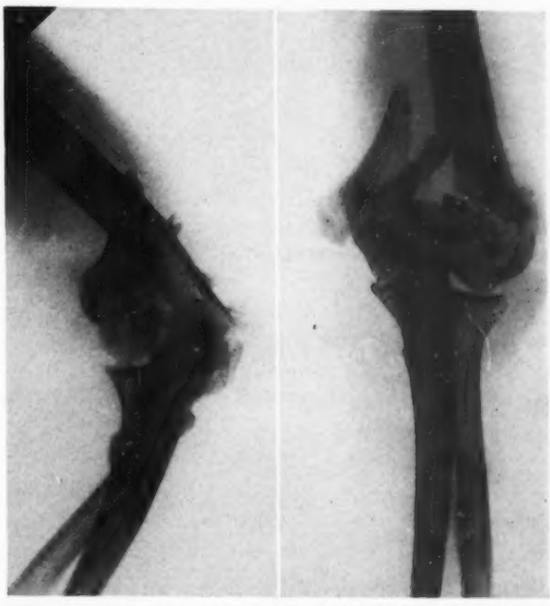

FIG. 1. Original x-ray showing multiple fragmentation.

With this problem before me I decided that the procedure was to be undertaken in two sittings: At the first there would be débridement of bone fragments and stabilization of the olecranon process over the remaining end of the humerus at a right angle while a prosthesis was being made which was to be incorporated as part of the elbow joint in order to obtain function. During this interval following débridement the wound was to be closed and fixed in plaster at 90 degrees flexion while the prosthesis was being made from vitallium® which was to be introduced at the second sitting.

With this protocol arranged, an elliptical incision was made in the skin flap with its attached base in the middle third of the arm above and terminating elliptically beyond the

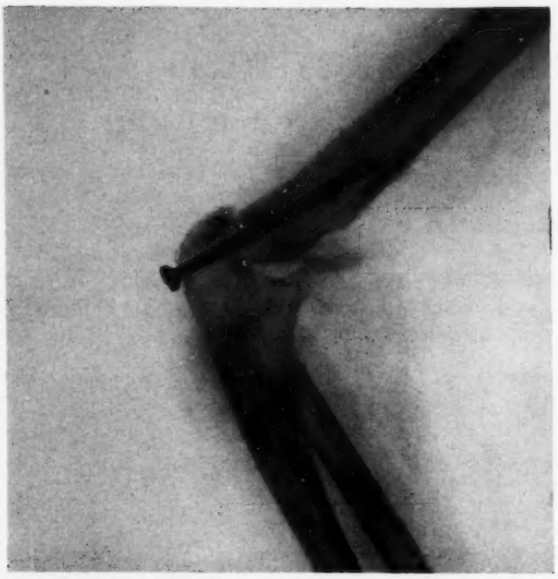

FIG. 2. This x-ray shows the skeletal arrangement at the elbow with the wound closed.

olecranon process below. The triceps with its fascia was exposed and incised in the long axis, which gave complete exposure to the fragmented bone and soft tissue about the lower end of the humerus which had been so severely traumatized.

As seen in Figure 1, the entire distal end of the humerus was totally destroyed but the olecranon process was not injured and the radial head was in normal articulation with the ulna; the capsule about the elbow with its synovia and lateral and mesial attachments, as seen through this exposure, was intact and left undisturbed, but from the distal end of the humerus sufficient débridement was necessary to level it off in order to receive and support the prosthesis which was to be substituted at the second sitting. When this was done, the olecranon process was fitted over the humeral end at an angle of 90 degrees and stabilized in that position with a long vitallium screw, which fitted it at a right angle to the remaining humeral shaft. The wound was then closed in layers and the extremity encased in plaster, to be held in that position until the prosthesis had been made and was ready for introduction at the final sitting. (Fig. 2.)

Now came a very difficult step in this procedure which was to try to assemble these fragments anatomically for a model, as best we could, by which to fashion a distal humeral end. However, the trochlear surface was too shattered to support the condyles in proper position to send to the Austenal Laboratories; the only semblance of a model that I could arrange was with an incomplete assembly of these fragments together with the x-rays of the shattered elbow. Measurements of the lower end of the humeral shaft had been taken at the first procedure so that the sleeve of the prosthesis fit, but the prosthetic end containing the olecranon fossa and humeral condyles was about 2 mm. too large, which you will note in the assembly. For that reason it was necessary to fracture the olecranon process at its base and displace it backward so that it could be fitted over the condylar end of the prosthesis. We must realize that a skiagram is the photograph of a shadow which varies in concert with the distance from and intensity of the light, the density of the intervening object and the background upon which the shadow is cast. In estimating the size of objects as seen in an x-ray film these factors must be taken into consideration. In this instance each of these fundamentals was unknown, as well as the intensity of the x-ray, so only by estimation could the size of this trochlear be made. In general the skiagram is 1, 2 or 3 mm. larger than the object photographed so that 3 mm. added to the actual measurement of the x-ray were too much and account for this error, which made the displacement of the olecranon process posteriorly necessary.

At the second procedure eleven weeks later the wound was reopened through the original incision and the olecranon process, and the radius and lower end of the humerus were freely exposed. The intervening soft tissue was separated to receive and ultimately cover the prosthesis now to be fitted over the remaining lower end of the humerus, which was equipped with a triangular intramedullary pin seated upon a transverse base in a semi-triangular sleeve. This sleeve was to be fitted over the humeral end and was provided with alternate openings to receive screws to be inserted transversely into the humeral shaft for better stabilization and the prevention of rotation. (Fig. 3.)

However, with the attempted engagement of the olecranon in the coronoid fossa, extension of the forearm was limited to 100 degrees as the trochlear was too large to receive the olecranon process. For this reason it was

FIG. 3. The olecranon as displaced posteriorly and stabilized by a vitallium screw receives the trochlear.

FIG. 4. This shows the head of the screw fixing the olecranon in new position before the final closure with the elbow in 90 degrees flexion.

FIG. 5. After closing; note medullary pin in sleeve engaging the humeral end; prosthesis engaged under the olecranon and the screw fixing the olecranon in its changed position.

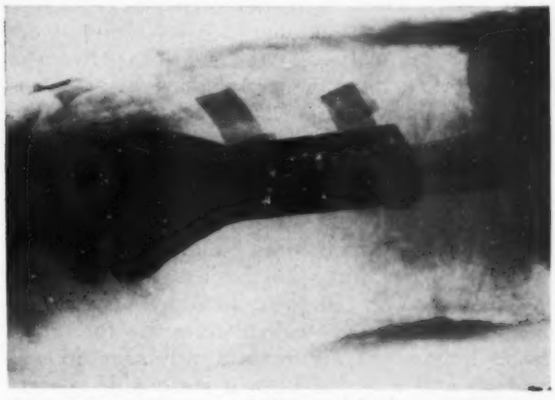

FIG. 6. Lateral x-ray of the prosthesis and elbow in extension.

necessary to fracture incompletely the olecranon process anteriorly (by rongeur) and angle it backward thus increasing its articular surface where it was held by a wing bolt screw during the procedure of further sitting and by final fixation in the elected position by a screw through the olecranon into the shaft of the ulna in the changed position.

In the final closure it was necessary to use fascial strips, which had been previously obtained from the thigh, to maintain engagement of the prosthesis in the desired position at the elbow; these strips of fascia were also looped and fastened through the prepared openings in the prosthesis to fix and stabilize all tissues in their anatomic arrangements without circulatory or neurologic interference. At the end the skin flap was sutured back into place, the wound closed for the second time and the elbow again fixed at 90 degrees of flexion with the forearm in semi-supination and the extremity encased in plaster in this position. (Figs. 4 to 6.)

Fifteen months later function at the elbow, which was stable, was from 110 degrees flexion to 180 degrees extension, while pronation and supination of the forearm were normal. At present the patient has about 80 per cent of the former use of his arm and tells me he will be able to play his violin again when a little more flexion is had. The oversized trochlear is the cause of the limited elbow flexion which I think will be gradually accommodated by diminished tissue tension.

Acknowledgment: I wish to express my appreciation to Dr. Max Bloom of San An-

tonio, Texas, for his helpful interest in this undertaking.

DISCUSSION OF PAPERS BY DRS. COUGHLIN, MAZET AND TAYLOR, CASSEBAUM AND VENABLE

AUGUSTUS THORNDIKE (Boston, Mass.): I am speaking from the point of view of the Veterans Administration research program. Dr. Mazet's paper discussed some sixteen new devices, but to go into a detailed discussion of them all does not seem appropriate.

The Government has spent between 3¼ and 4 million dollars on this prosthetic research. The upper extremity research activity is located in Los Angeles. This group is very happy to report that they have produced a prosthesis that weighs 2 pounds, 3 ounces for an above-elbow instead of the 7 to 9 pound device that was available before.

The end devices have been improved. I would like to describe a little how one has to have a new device approved by the Committee on Artificial Limbs. The inventor presents his device to one of our testing laboratories; there are only two or three models available at that time. We work over the device and try it on two pilot wearers; and when we are satisfied, the National Research Council orders more devices made. Following this, we have what we call a "shakedown test," during which five or six models are tested in our laboratory and on pilot wearers. After that test, which will run at least ninety days, if it seems to be good we provide a field test which means somewhere between eighty and one hundred devices are presented to our thirty prosthetic teams throughout the country to try the device in all sorts of environment of weather and otherwise, again for ninety days. Following this reports are sent in and studied; and if it has been a reasonable success, can be fitted by the limb industry in these thirty areas and the pilot wearers can be trained in its use and are satisfied with it, we then are ready to accept it.

The National Research Council will recommend to us in the Veterans Administration that it be accepted. However, we do not feel compelled to do so under those circumstances, and I might say that twice we have insisted on further field testing before accepting, namely, with the suction socket above-knee artificial leg and with the APRL hook.

The problem of getting these devices through a production line engineering test is the important one. They look very simple when they are handmade but we have had trouble and we now have trouble with this Northrup hook you saw this morning, which we thought was all right. The production engineer believes it has to be 2 ounces heavier and a little larger. Therefore, it is not so simple to produce a new device that can be said to be acceptable.

The cost of the devices might interest you. The plastic artificial arm, above-elbow type, at the manufacturer's level is $120. Regarding the gloved hand of the Army Prosthetic Research Laboratory, we are now getting bids from the industry on that which vary from $175 to $275 for the hand alone. So you can see we have our troubles trying to get cooperation from the industry in getting this out at a reasonable price.

I just want to close by saying that this is a very interesting undertaking that I seem to be involved in, and I want to thank Dr. Mazet for presenting the report.

G. W. N. EGGERS (Galveston, Tex.): I just wanted to ask Dr. Cassebaum a question with regard to his elbow operative procedure. We have followed a policy of transplanting the ulnar nerve routinely to the anterior surface of the cubitol area because of the occurrence of late ulna involvement. I think one of the cases did show an involvement of the ulnar nerve. I was wondering what his experience was in regard to the routine transplantation of this nerve, whether or not he does it. We have transplanted the ulnar nerve from the posterior surface of the arm to the anterior surface in all these traumatic lesions so as to avoid the delayed ulnar paralysis with its sensory disruptions and later its motor involvement. I do not know what the general attitude is, but we thought the nerve transplant a rather logical policy because these cases usually have impaired elbow extension. Perhaps he could enlighten us a bit more on his experience with it.

FREDERICK M. SMITH (New York, N. Y.): As far as intercondylar fractures of the lower humerus are concerned, they are in general, of two types, one which can be operated upon and one which cannot. Dr. Cassebaum has shown us a very excellent group in which he has done open reduction with internal fixation, and I think with truly remarkable results. They have really been beautiful.

I believe a good deal of his success is due to the type of incision he has used, getting a very thorough exposure by means of the transolecranon approach which permits him to take the ulnar nerve away from its bed, draw it out of the field temporarily, reassemble the condylar fractures and hold them while they are fastened rigidly by internal fixation, then repairing the olecranon by means of a screw. We have done this in perhaps eight to ten similar fractures. We have not used the transolecranon approach but I think it is better than the incision we have used. We have usually tried to go on either side of the triceps tendon or on both sides of the triceps tendon, and sometimes one may run into difficulty.

There is, however, a form of intercondylar fracture which it is really impossible to fasten by internal fixation. This is the badly comminuted type with six or more fragments. In such a fracture we have not had the courage to go in, because in the one or two we tried we found we could not get good internal fixation and the fragments come apart. The procedure then was defeated. The elbow had to be put in plaster and subsequently became stiff or very largely stiff.

We have put these fractures in overhead Kirschner wire traction. This type of suspension permits motion while in suspension, and those patients will retain a very sizable amount of their original motion. They will get perhaps from 50 to 60 degrees of flexion to 150 to 160 degrees of extension, and we believe that is much better than an elbow that is stiff.

GORDON MCK. MORRISON (Boston, Mass.): I very much enjoyed the papers given by Drs. Coughlin, Mazet, Cassebaum and Venable, and congratulate them.

In Dr. Coughlin's paper he certainly showed some rather unusual injuries. How often do we see a medial tibial condyle? Frankly, I see a lot of lateral tibial condyles but rarely the inner one injured.

Also, I find peroneal nerve palsy extremely rare and I have wondered many times, with these so-called bumper or fender fractures, why we do not see that injury far more often than we do.

I should like to refer to the matter of a bone bank. I think that should be pushed across the country more than it has been. If you have a deep freeze in town, you can run a bone bank.

The proper timing of treatment to avoid disastrous complications was stressed by Dr. Coughlin, and I think that is very important. We have all been guilty at one time or another of delaying treatment, fearful of starting because the patient was in shock. Granted that we have all had it drummed into our heads to refrain from treating a patient in shock other than for the shock, I am sure that we take far too long getting to some of these open fractures.

Dr. Coughlin mentioned a simple fracture and of course there is no such thing; fractures are closed and open. I hope Dr. Coughlin does not mind my correcting that statement.

END RESULTS OF LOW BACK SURGERY

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THE purpose of this paper is to present and especially to compare the end results obtained in a relatively large series of cases from the more common surgical operations employed in the treatment of nontracture injuries of the low back. The cases upon which this report is based include all such examples disclosed by a review of the Oregon State Industrial Accident Commission records. Only those factors were selected for consideration which most clearly and unequivocally present a precise and accurate reflection of results actually obtained.

GENERAL CONSIDERATIONS

This study comprises 417 cases of which nineteen, or 4.6 per cent, were females. The average age of this series was 37.6 years. Fifty-one point eight per cent were between the ages of thirty and forty years inclusive. Ninety point two per cent of these claims were closed between the years 1938 and 1950 inclusive, while 35.7 per cent were terminated subsequent to 1948. The average time elapsing between surgery and the present is 5.6 years.

Segregated in accordance with the type of surgery carried out, these 417 cases fall into the following five categories: (1) Partial hemilaminectomy for protruded intervertebral disc, 129 or 30.9 per cent; (2) partial hemilaminectomy and spinal fusion done at the same operation (combined operation), 106 or 25.4 per cent; (3) spinal fusion only, 164 or 39.3 per cent; (4) partial hemilaminectomy plus subsequent spinal fusion, 14 or 3.4 per cent; (5) spinal fusion plus subsequent disc surgery, 4 or 1.0 per cent.

With extremely few exceptions disc surgery was carried out exclusively by neurosurgeons, spinal fusion by orthopedic surgeons, while in the combined operation the two specialties collaborated. Five neurosurgeons and twenty-eight orthopedic surgeons comprised the operating personnel.

The severity of the initial trauma was essentially the same in all categories; no one group contained a preponderance of more or less seriously injured patients. The average injury was not impressive and in the majority consisted of lifting strains, slips and falls from a standing height.

Disability evaluations were made by members of the Commissions's medical staff. No group of these patients was directed to any particular examiner. Criticisms of this method of disability evaluation or of the standards employed for the measurement of disability have no validity insofar as comparisons are concerned, inasmuch as all patients were subjected to the same type of evaluation, and disability is expressed by the same standards of measurement. In no instance was the examiner and the operating surgeon the same individual.

Under the Oregon Workmen's Compensation Act permanent total disability indicates that the workman is disabled to an extent which no longer permits him to engage in a gainful employment. Disability levels less than total are evaluated under this act in terms of percentage loss of function of an arm.

In addition to the groups included in Table 1 there were two categories which could not properly be combined with the foregoing and which contained too few examples to support statistical conclusions. In the interests of completeness these follow:

There were fourteen cases of partial hemilaminectomy followed subsequently by spinal fusion. Two, or 14.3 per cent, were permanently and totally disabled. The remaining twelve were partially disabled, the average of which was 55.8 per cent of an arm. Two of these, 14.3 per cent, resorted to legal action following claim closure.

Four cases of spinal fusion were followed subsequently by disc surgery. One of these, 25.0 per cent, was totally disabled, and of the three partial disabilities the average was 71.7 per cent of an arm. There was no legal appeal in this group.

COMMENTS

Comparison of the first two columns of Table 1 reveals that the addition of spinal

fusion to intervertebral disc surgery results in an increase of 53.3 per cent in the time loss following surgery, an increase of 44.6 per cent in the time elapsing before the patient's condition becomes stationary, an increase of 22.5 per cent in the permanent total disability rate, an increase of 38.2 per cent in permanent partial disability, an increase of 33.2 per cent in the disability total and an increase of 35.0 per cent in the rate of those resorting to legal action. These concrete and considerable disadvantages are not offset by the group of fourteen disc surgery cases in whom it was later thought desirable to do a spinal fusion. Especially is this true when we note that the additional surgery still failed to relieve a large degree of their disability, as indicated by a permanent total disability incidence of 14.3 per cent and a permanent partial disability average of 55.8 per cent of an arm in this small series. None of these fourteen cases represented an instance of disc recurrence at the site of the original protrusion.

Comparison of the last two columns of Table 1 reveals that the results obtained from spinal fusion are substantially improved when this operation is done in conjunction with disc surgery. This results from the fact that many patients in the combined operation group were suffering from definite disc protrusion. Their symptoms were relieved with the removal of the offending disc. There is every reason to believe, however, that had the spinal fusion been entirely omitted and only disc surgery carried out the result would have been still further improved.

TABLE 1
TABULAR COMPARISON OF RESULTS

	Disc Surgery (129 Cases)	Combined Operation (106 Cases)	Spinal Fusion (164 Cases)
Time loss from surgery to resumption of occupation	6.0 mo.	9.2 mo.	10.2 mo.
Time elapsing from surgery to claim closure	8.3 mo.	12.0 mo.	13.2 mo.
Permanent total disability*	4 cases	4 cases	23 cases
	3.1%	3.8%	14.0%
Permanent partial disability† (% of an arm)	125 cases	102 cases	141 cases
	33.8% of an arm	46.7% of an arm	51.7% of an arm
Disability total‡ (% of an arm)	129 cases	106 cases	164 cases
	44.3% of an arm	59.0% of an arm	96.9% of an arm
Legal action§	18 cases	20 cases	52 cases
	14.0%	18.9%	31.7%

* Denotes a disability level incompatible with further gainful employment.

† Indicates a percentage loss of function of an arm to which patient's disability is equivalent.

‡ A wholly artificial figure presented here to facilitate comparison by combining permanent total disability into terms of percentage loss of function of an arm in the ratio that the cost of the average permanent total disability claim bears to the legal value of an arm.

§ May be taken as an index of the patient's dissatisfaction with his result. Under this heading the number and per cent of patients in each group who employed an attorney for the purpose of contesting their claim closure and disability is given.

The success of spinal fusion in alleviating back disability resulting from industrial injuries, as indicated by this series of cases, leaves much to be desired. It is our impression that failure to secure solid and permanent bony union is far more common than generally suspected and is in fact the principal cause of these poor results. Spinal fusion, involving as it does only the posterior spinal elements, results in the bony union thus produced being at a tremendous mechanical disadvantage. The relatively massive lumbar vertebral bodies, bearing the superincumbent body weight and resting upon elastic intervertebral structures, are left free to transmit stresses through the pedicles directly to the fusion mass. These stresses are undoubtedly great, especially in those engaged in heavy manual labor. This combination of marked stress coupled with mechanical disadvantage may well result in the

formation of fine fissure fractures which have been repeatedly described in other bones subjected to unusual strains and variously termed march fractures, fatigue fractures and stress deossification. These irregular fissures passing through the fusion mass may not be discernible on the roentgenogram and may not give rise to sufficient motion to be demonstrable by flexion films. It may be that the theoretic value which might be expected from spinal fusion in the lower lumbar area will not be fully realized until some technically practical and surgically sound method of producing solid bony union between these vertebral bodies and those of the sacrum is devised.

While in some instances it may be desirable as a result of poor spinal architecture to add spinal fusion to disc surgery for purely mechanical reasons, the indication should, however, be independent of the existence of any pathologic condition of the disc. This series of cases does not support the practice of routinely combining spinal fusion with disc surgery; on the contrary, it presents many sound reasons for not doing so.

EARLY MOBILIZATION IN TREATMENT OF OS CALCIS FRACTURES

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Cincinnati, Ohio

THIS presentation is confined to a method of treatment in which after a molding type of reduction, the cast is applied and left on for ten days only. Active motion of the foot is begun as soon as the cast is removed. It seems to us most unfortunate that we have forgotten Cotton's method or have put it aside for the more dramatic pin fixation as advocated by Bohler in 1929.

Ours is not an original idea; neither is it new. In 1908 Cotton wrote "Fracture of the Os Calcis" in which he made important observations concerning lateral movements of the foot. He stated that pronation and supination are movements occurring purely between the astragalus and the calcaneus. In fresh os calsis fractures there is limitation of this motion and many times is completely absent. The thickness that can be palpated below the lateral malleolus is not soft tissue swelling but a spreading of the bone plate which seems to be nearly pathognomonic of this fracture. Cotton further advocated daily removal of the cast after ten days for active motion of the foot but he reapplied the cast in the interval. We see no reason for this and advocate leaving off all support after ten to fourteen days but denying weight bearing.

We are sure that in most cases of os calcis fracture there is some degree of injury to the talocalcaneal joint and usually this derangement is severe. As the fracture occurs by downward crushing, the result is lateral spreading of the bone at the joint. Impacting the os calcis from the sides to restore the anatomy of the area is as much as we can do. The subastragular is an arthrodial or gliding joint and we believe prolonged immobilization tends to freeze it. Follow-up of os calcis fracture in which long immobilization was used has shown, at least to us, that lateral motion of the foot is either badly impaired or entirely missing. We have had many complaints from these patients about their inability to walk well on uneven terrain. They say that forcible pronation or supination, as for example stepping on small stones or other objects, causes severe pain below the lateral malleolus and into the talocalcaneal joint.

We were not happy with these complaints and decided to abandon Bohler's way and try something different. In October, 1949, we treated the first os calcis of this series. The reduction procedure was the same as advocated by Cotton. We removed the cast entirely on the tenth day and got the patient moving his foot in all directions but he was denied weight bearing. We were highly pleased to find that these movements were almost without pain and that in a few days the motion was restored almost to normal with no discomfort. Weight bearing with or without arch support was begun in eight weeks. Crutches or cane was frequently eliminated at that time or soon after.

We have treated twenty-six patients in this manner. These included, among others, railroad switchmen, railroad bridge carpenters, steam fitters, painters, bricklayers and others who fell from ladders. Incidently two of these cases were complicated with other fractures of the long bones of the opposite leg.

We have been able to follow up all of the cases for eight weeks or more and several for over a year. We can report that all of them have fair to good lateral motion without pain. One patient has no pain in his talocalcaneal joint but does have some discomfort in the dorsum of his foot following along the fourth metatarsal bone. As a matter of speculation we think that none of our patients are having trouble because we believe that if they were they would be back complaining. We are giving you these findings because we think our os calcis fractures have done a good deal better under this form of treatment than any other we have tried to date.

SUMMARY

Cotton's method with early removal of the cast and active lateral motion of the foot,

we believe, is far superior to the pin method and long immobilization.

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INDICATIONS AND CONTRAINDICATIONS FOR THE PLASTER OF PARIS WALKING BOOT

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IN the treatment of fractures as in every other field of surgery there has been in recent years an increasing interest in early ambulation. One of the most popular implementations of this principle is the plaster of paris weight-bearing or "walking" boot for injuries to bones and ligaments below the knee. When indicated and properly applied it is one of the most useful splints in the surgeon's armamentarium, often restoring the patient to functional self-sufficiency within a few days of injury. But it has definite limitations beyond which it can do more harm than good.

A survey of currently popular textbooks discloses considerable variance in recommended indications and contraindications for the plaster of paris walking boot. Some authorities avoid the issue;[1–3] others are vague.[4–6] Many recommend early weight-bearing in short leg casts for various ankle fractures and fractures of the shafts of both bones of the leg.[7–14] Few are as definite as Watson-Jones[15] who states that "a short below the knee plaster is not safe at any time in the treatment of fractures of both bones of the leg," or Stimson[16] who advises that a walking boot should never be used in the treatment of fractures of both malleoli.

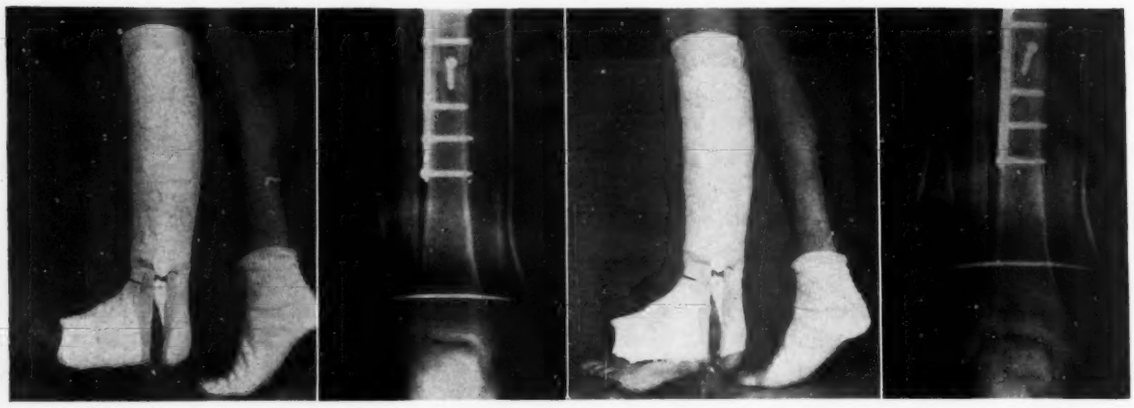
Although Krause[17,18] was the first to employ the walking cast, it was Delbet[19] who first introduced the concept that weight was borne largely, if not entirely, on the flaring upper end of the tibia and the head of the fibula. Delbet's walking plaster splint for fractures of the leg has deservedly fallen into disrepute and the reasons are not far to seek. In the great majority of individuals the flare of the upper end of the tibia is filled or even obliterated by muscle except on its anteromedial aspect. Also the prominence of the head of the fibula is, as a rule, directly continuous with that of the extensor musculature. In any event the skin and subcutaneous tissues are lax in this area and it is difficult to see how any weight-bearing device could achieve a very secure purchase on these slight bony prominences in the great majority of individuals. Even if such anchorage could be obtained, the peroneal nerve would be in danger since it winds about the upper end of the fibula at the point where the cast would exert its greatest contact. Evidence in support of this point of view was obtained by a simple experiment:

CASE 1. A healthy, young man who had been subjected to open reduction and internal fixation of a fracture of the lower tibia and fibula twelve weeks previously was selected. A plaster of paris walking boot was applied with only one layer of thin stockinette as padding. A strip of lead was incorporated into the plaster parallel to and about 2 cm. above the ankle joint. A U-shaped walking iron was incorporated into the plaster. Weight-bearing was not permitted for forty-eight hours at which time the cast was firm and dry.

The sole of the plaster boot was then removed and x-rays and photographs were taken with the patient bearing full weight as in an ordinary step. It was seen (Figs. 1 to 4) that the foot slipped down through the cast for approximately 1 cm. and the plate on the tibia approached the piece of lead in the plaster cast by the same distance. During the procedure the patient complained of discomfort at the malleoli. The cast was then removed from a level just above the malleoli and weight was again borne on the leg. (Figs. 5 and 6.) The leg slipped easily through the remaining cast and was checked only by impingement of plaster against the patella.

It was, therefore, apparent that weight is borne primarily on the sole of the foot and the malleoli in a plaster walking boot and only very little on the upper end of the tibia and fibula.

Another basic consideration which is often disregarded in using the plaster boot is that of immobilization of joints proximal and distal to a fracture. The boot fixes the ankle joint firmly and the projecting foot acts as a lever which serves to twist the ankle joint, tibia and fibula at every step. That such torsion is



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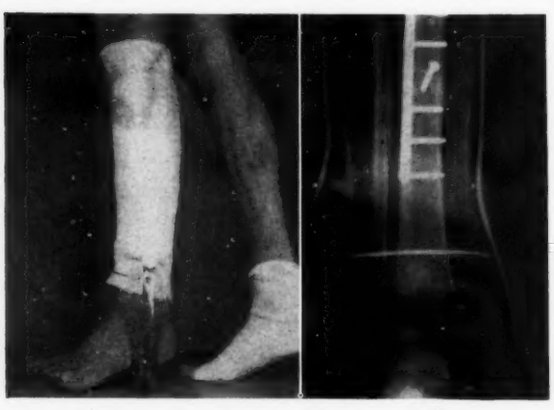
FIGS. 1 and 2. Unpadded plaster walking boot applied to a healing fracture of the tibia and fibula which had been treated with primary open reduction and internal fixation. A strip of lead had been incorporated into the cast parallel to and just above the ankle joint.
FIGS. 3 and 4. The sole of the walking boot has been removed; note that the heel has slipped downward and the distance between the lead in the cast and the plate on the tibia has decreased.



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FIGS. 5 and 6. The cast has been removed from above the malleoli; the leg slips through the cast and is checked only by its impingement on the patella.

communicated to the fracture site in fractures of the shafts of the tiba and fibula is illustrated by the following experiment:

CASE II. The well muscled leg of a sixty year old man was amputated for Buerger's disease at the junction of the lower and middle-thirds of the femur. The femur of the amputated extremity was firmly fixed to a heavy block of wood by two heavy transfixing pins. Two screws were placed in the tibia in the sagittal plane at the junction of the upper and middle-thirds and at the junction of the lower and middle-thirds of the bone. A fracture of both bones midway between the screws was produced, an unpadded plaster of paris boot was applied and anteroposterior x-rays were taken. (Figs. 7 and 8.) The distal end of the cast was gently rotated, externally and internally and further x-rays were taken, as seen in Figures 9 and

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FIGS. 7 and 8. A recently amputated leg fixed to a heavy block of wood; fractures have been created in the middle-third of the tibia and fibula and screws inserted in the sagittal plane in the tibia above and below the fracture. An unpadded plaster of paris boot has been applied.

10. It was seen that while a certain amount of rotation in each direction was communicated to the upper portion of the tibia a much greater degree

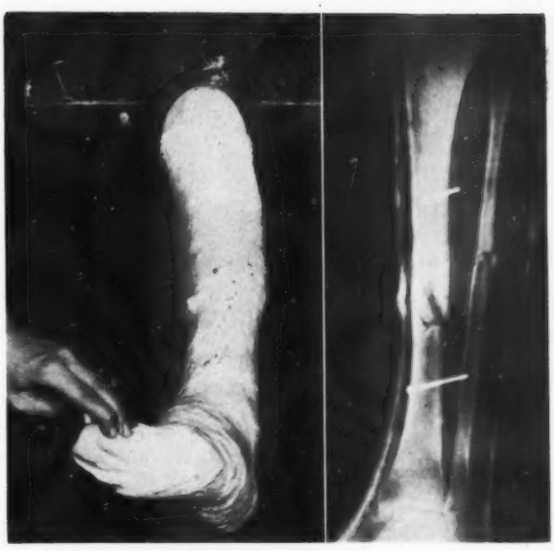
took place in the lower portion and in each instance displacement occurred at the fracture site.

From a clinical point of view the hazards of ill-advised use of a plaster of paris walking boot are illustrated by the following cases:

CASE III. J. W., a forty-six year old technician, fell twisting his right ankle. An x-ray film taken on the day of injury (Fig. 11) showed a complete oblique fracture of the lower end of the fibula with minimal displacement. The anterior aspect of the fracture line was at the level of the superior surface of the astragalus.

There was considerable swelling of the joint. The patient was admitted to a hospital, a compression dressing was applied and the foot was elevated. Five days after the accident an unpadded plaster of paris boot was applied with a walking heel. X-rays one month later (Fig. 12) disclosed lateral displacement of the distal fragment of the fibula with widening of the joint mortise. The deformity was corrected at operation a few days later.

CASE IV. W. McS., a thirty-six year old workman, was admitted to a hospital one hour after sustaining a fall on an icy street. X-rays disclosed a complete oblique fracture through the tibia at the junction of the middle and lower-thirds and a long oblique comminuted fracture through the upper end of the fibula. (Fig. 13.) On the day after admission open reduction and internal fixation of the tibial fracture was carried out. Postoperative x-ray films showed excellent re-position of the fragments. (Fig. 14.) X-rays three months after operation showed no change in the position of the fragments. The full leg cast which had been present since operation was removed and a short leg cast applied with a walking heel. Ten days later the patient complained of pain at the fracture site. X-rays (Fig. 15) showed displacement of the fragments and bending of the plate. Weight bearing was immediately discontinued. Healing progressed very slowly and seven months after injury the patient was allowed to walk once more. Again pain occurred together with tenderness and redness at the fracture site. There was no fever or leukocytosis. The patient was re-admitted to the hospital and the plate was removed. When last seen fifteen months after the injury, there was still pain on walking and tender at the fracture site. X-rays showed exuberant callus but the fracture line was still visible. (Fig. 16.)



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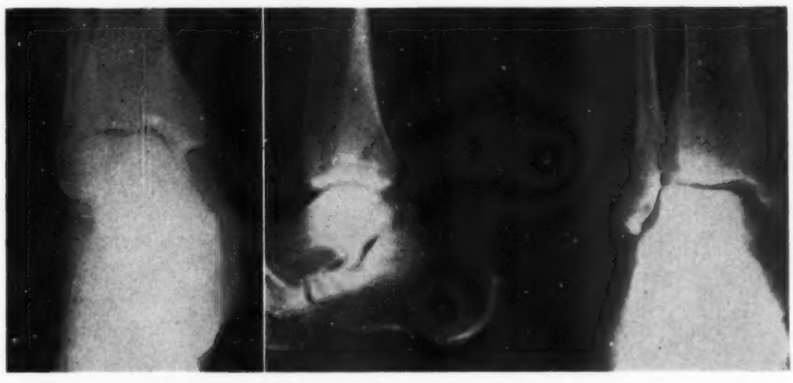
FIGS. 9 and 10. The leg and plaster are forced in moderate internal rotation.



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FIGS. 11 and 12. Fracture of the distal fibula at the joint line treated with an unpadded plaster walking boot; lateral displacement of the fragment and widening of the joint mortise first noticed three weeks later.

This case illustrates the effect of the torsion at the fracture site on fractures of both bones of the leg. Had the fracture not been subjected to the rotary stresses and strains of weight-

FIGS. 13 to 16. Case II, spiral fracture of the tibia and fibula treated with primary open reduction, internal fixation and a full leg plaster cast. Three months later a plaster walking boot was applied, with recurrence of deformity. Disability was still present at eighteen months with roentgen evidence of malunion.

bearing, there is every reason to believe that healing would have progressed without event despite the possible deficiencies of the plate and screws.

CASE V. J. M.* sustained a compound fracture of the tibia and fibula which was débrided and fixed with pins above and below the fracture site and a plaster of paris cast extending from toes to groin. (Fig. 17.) Two months later the pins and plaster were removed and a light, below-the-knee plaster boot was applied. One month thereafter, approximately three months after fracture, a walking device was incorporated into the plaster boot. Three months later (approximately six months after the injury) the patient slipped and fell sustaining a spiral fracture of the femur and a refracture of the tibia and fibula. (Fig. 18.) Plating of the femur and a bone graft to the tibia were necessary. Eventual union occurred a year after the original injury.

This case represents the powerful effect of torsion produced by the plaster of paris walking boot. Had immobilization of the joint above and below the fracture been continued, fracture of the femur in all probability would not have occurred.

* Data on this case were furnished by Dr. Harrison McLaughlin of the Presbyterian Hospital, New York, New York.

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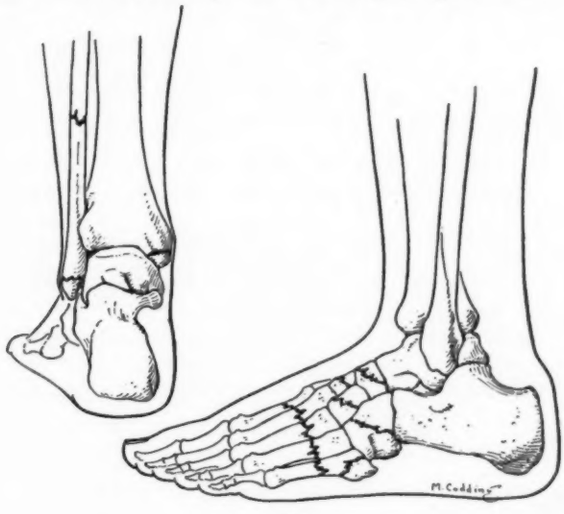
FIGS. 17 and 18. Case III, compound fracture of the tibia and fibula treated with débridement, pin fixation and a plaster walking boot; stress resulting from weight bearing eventually produced the spiral fracture of the femur on the right.

FIG. 21. External rotation and eversion of the leg and foot; the result of a walking device bearing the weight on a single point.

COMMENTS

Notwithstanding this experimental and clinical evidence pointing to the dangers inherent in the plaster walking boot, all surgeons will recall instances in which the boot was used contrary to these principles and without trouble. In other words, at times it is possible to "get away" with a plaster walking boot when its use should be contraindicated on theoretic grounds. However, it must be accepted that if a method of treatment of a fracture carries a risk of deformity, that risk must contraindicate the method unless outweighed by other factors.



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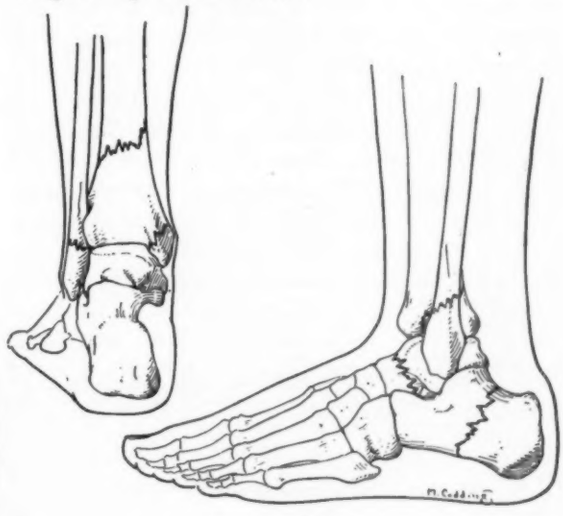

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FIG. 19. Indications for the plaster of paris walking boot.
FIG. 20. Contraindications for the plaster of paris walking boot.

Bearing these considerations in mind it is possible to formulate certain fairly definite indications and contraindications for the plaster of paris walking or weight-bearing boot:

Indications. (Fig. 19.) These can be listed as (1) fractures of the fibula above the level of the distal tibiofibular ligaments; (2) fractures of the malleoli below the level of the superior surface of the astragalus and (3) most fractures of the bones of the foot distal to the talus and os calcis.

Contraindications. (Fig. 20.) The contraindications are (1) fractures of the both bones of the leg at any stage of healing; (2) fractures of the malleoli which if displaced might result in widening of the joint mortise; (3) fractures of the os calcis or talus and (4) fractures of the distal weight-bearing articular surface of the tibia.

These can be expressed even more simply in another way. If the surgeon in analyzing a fracture below the knee will ask himself whether weight bearing can in any way endanger the position of the fragments, the decision as to whether or not a plaster of paris walking boot can be used is easy. He should also remember that if immobilization is adopted as a method of treatment, it must include the joint proximal and the joint distal to the fracture.

Once a decision to use a weight-bearing boot has been made, the type of weight-bearing device must be considered. The worst possible arrangement is the single point crutch tip which not only permits but encourages violent torsion at every step and can produce a habit of eversion and external rotation in walking which may be difficult to correct. (Fig. 21.) The ideal weight-bearing device should permit a close approach to normal heel-toe walking. This can be achieved by various rockers, special shoes, or simply an inexpensive bypiece of old automobile tire and sponge rubber.[20]

SUMMARY

1. Clinical and experimental evidence is presented illustrating the hazards of ill-advised use of the plaster of paris walking boot.

2. Indications and contraindications for the use of the walking boot are discussed.

3. The importance of normal heel-toe walking when a plaster weight bearing boot is used is emphasized.

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AN EVALUATION OF SLIDING BONE GRAFTS OF THE TIBIA*

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SINCE Albee popularized the inlay graft for the treatment of ununited fractures, there have been conflicting reports on its usefulness. For some years the onlay graft of cortical bone, multiple iliac grafts of cancellous bone and, since the recent war, massive onlay grafts have been more popular, indicating a high rate of failure with the inlaid sliding cortical graft. Henderson,[7] Campbell[4] and Key[8] in the treatment of delayed and non-union of long bones reported better results with massive autogenous onlay grafts fixed with screws. Bishop et al.[2] stated that "inlay grafts should be used only in cases of delayed union where an actual healing process is already present." Armstrong[1] stated that for the tibia "the sliding inlay graft is particularly unsatisfactory."

It is generally agreed that successful grafting depends on many factors such as the presence of good coverage with normal skin and subcutaneous tissue in the operative area, absence of infection, minimal trauma during operation, use of a large piece of autogenous (or homogenous) bone fixed across the fracture site, good apposition of the graft to raw bleeding bone of the host and continuous immobilization until healing is well advanced. The authors believe that for the tibia, except in rare situations, the sliding inlay bone graft fulfills the criteria. In 1946 Day[6] reported on the results of treatment of 100 consecutive fresh fractures of the tibia and emphasized that the sliding inlay graft fixed by steel screws was the method of choice for the initial treatment of simple, transverse, unstable fractures requiring more than simple screw fixation. Burns and Michaelis,[3] by means of the sliding inlay graft, have treated delayed and non-union of the tibia successfully in twenty-five of twenty-six consecutive cases since 1940, and Wallace[10] has recently reported similar success in the treatment of old warfare fractures which previously had long-standing infection.

The present report is based on a study of twenty-five consecutive sliding inlay grafts of the tibia performed since 1946. It is believed that the results suggest a greater usefulness than is generally recognized and that recent changes in technic make the operation more successful than when first introduced. Patients were selected for operation who had good skin coverage and had no evidence of open wounds or infection for at least two months prior to operation. Of the twenty-five cases five were for recent unstable fractures, three for delayed union, sixteen for non-union and one for malunion. With four exceptions these were originally compound fractures. Of nineteen patients operated upon for delayed or non-union, the original treatment in each was as follows: traction eight, plates two, screws two, inadequate immobilization one, and manipulation and continuous plaster four; in two cases original treatment was unknown. The operation performed in twenty-one cases was a classical sliding graft, in which the graft was fixed across the fracture site with SMO stainless steel screws with wide wood-type threads. Three times additional iliac bone was packed about the fracture or was used to fill a gap, and once a massive sliding graft was used.

It is believed that the following technical points are important factors in achieving success. The major graft is cut at least 5 inches long and ¾ inch wide, and the minor graft 2½ by ¾ inch. The grafts are cut with the motor saw using a single blade held at such an angle that the graft is beveled. The double blade saw is never used. When the major fragment is fitted across the fracture site, the bevel prevents it from falling into the marrow space. The bevel likewise makes it possible to fix the graft to the major fragments with two screws above and below the fracture line.

When the operation was performed for delayed union and when alignment and apposi-

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tion were satisfactory, the fibrous callus was not disturbed and the fragment ends were not completely mobilized. However, in the unstable fresh fractures and in the cases of non-union and delayed union with poor alignment the fragment ends were dissected free, the marrow space was freely opened and accurate reduction was achieved. It was occasionally necessary to sacrifice some length in cutting the major fragment ends with the motor saw to get good apposition.

TABLE 1
SLIDING GRAFTS

Reason for Operation	Healing Time (mo.)
13 non-union	9.
3 delayed union	5.3
5 recent fractures	6.1
1 malunion	7.

Of the twenty-five cases twenty-two have progressed to complete unrestricted weight bearing. There were three failures. One patient did not report for follow-up care but had a second operation at another hospital. The other two were followed up and reoperated upon when failure was obvious. The average healing time in months, up to unrestricted weight bearing, is listed in Table 1.

Regarding the two failures followed up, the first had originally a compound comminuted war fracture which became infected and slowly healed following pedicle flaps and multiple sequestrectomies. The patient had been walking for fifteen months when he refractured the leg through the old fracture site in the lower third of the tibia. There was marked sclerosis and no medullary cavity. Following progressive absorption of bone during plaster immobilization he was treated by means of a sliding graft with additional iliac bone packed about the fracture. Eleven months later union seemed firm and he began full weight bearing. After one month of weight bearing he noticed pain and films revealed a fracture through the graft area. He has since been reoperated upon and the fracture appears to be uniting.

The second failure was that of non-union at the lower third of the tibia of six years' duration, with marked sclerosis at the fracture site and marked osteoporosis proximally and distally. The original reduction was by traction with transfixion pins in the os calcis and upper tibia and plaster immobilization. One year later the patient had a sliding graft fixed with Parham bands for non-union. Eighteen months following that operation while in a walking caliper he slipped and refractured the leg. At this institution he had a massive sliding graft. Approximately six months after the operation fracture of the graft was noted. Progressive absorption and sclerosis at the fracture site followed. However, it has been two years since the last operation; the patient is using a walking caliper, is free of pain and the fracture line is filling in.

The other complications in this series included two significant infections and one fracture of the graft. One of the infections occurred in a compound comminuted fracture operated upon four months after the original injury because of over-riding of the fragments and the absence of any healing. Despite the infection and following removal of the screws and sequestrectomy, there was solid bony union and complete soft tissue healing in sixteen months. The second postoperative infection occurred in a non-union of two years' duration. The lower two screws were removed, the wound healed and solid union followed in 8.5 months from the original operation.

One graft fractured immediately following surgery, presumably due to poor handling of the extremity. On continuous immobilization union was delayed but complete in eleven months.

COMMENTS

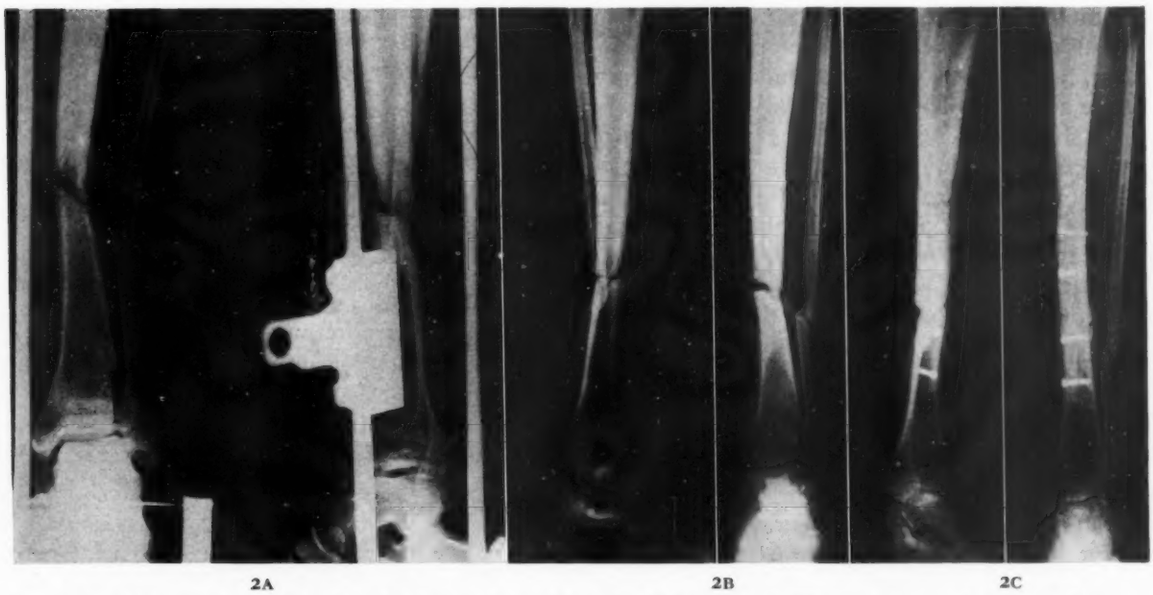
It is believed that these results and others recently reported indicate that the sliding inlay graft fixed with metal screws is an excellent procedure for the treatment of recent unstable fractures, delayed union and all but the most complicated non-unions of the tibia. With such treatment it is unnecessary to disturb the sound leg while it is still possible to bridge and fix the fracture with autogenous cortical bone. Since the medullary cavity is widely opened, there is the additional advantage of having apposition of the cancellous portion of the graft to that of the host. The superficial position of the medial surface of the tibia makes it easy to cut the graft; and since the graft is inlaid, there is no increased bulk to make wound closure difficult or to interfere with healing. (Figs. 1 to 3.)

The two failures were discussed in detail because it is believed that they were unusual fracture problems and failure might have been anticipated following any type of bone graft.

It is suggested that the sliding graft as now performed should be more successful than when first introduced. The technic of cutting a beveled graft makes a cabinetmaker's fit un-

1A 1B

FIG. 1. This case illustrates the use of the sliding graft in a fresh unstable fracture. This was a compound double fracture treated in skeletal traction for two months, at which time the skin was well healed (A). B, there was solid bony union six months after surgery.



2A 2B 2C

FIG. 2. In this type of case it is thought that early grafting should be advised. The patient was first seen after two months of skeletal traction for a compound fracture (A), at which time delayed or non-union could be predicted. The leg was immobilized in plaster for an additional five months, with no healing (B). When the skin maceration was treated, he had a sliding bone graft. Full weight bearing was possible eight months later (C).

3A 3B

FIG. 3. When first seen this was a non-union of two years' duration with marked sclerosis at the fracture site (A). Despite postoperative infection full weight bearing was started in 8.5 months. Because of persistent drainage and the reaction about the lower two screws noted here (B) the screws were removed and the infection controlled.

necessary and prevents the graft from falling into the marrow space.The beveled graft can be cut only with the single blade saw since the saw cuts are not parallel. In fact the double blade saw supplied with motor saws originates from the Albee operation and the Albee bone saw and should probably be eliminated from the motor saw accessories. It is possible now to fix the graft with stainless steel screws of uniform composition which produce little if any tissue reaction. Those screws also aid by producing compression between the graft and host bone. Although fractures of the graft due primarily to osteoporosis do occur and have been stressed as a cause of failure,[5] it is believed that the danger can be minimized by careful handling of the extremity. Finally, it is recognized that the availability of antibiotics contributes to better results.

A study of the healing time up to full weight bearing in those patients with delayed union and recent unstable fractures reveals that union progressed at rates comparable to those noted by others in uncomplicated, unoperated fractures. It is believed that when open reduction becomes necessary it is better to use an osteogenic bone graft for fixation rather than a metal plate or multiple pins. It is also thought that rather than wait for established non-union it is wise to suggest early bone grafting in those fractures which are known to heal poorly, after sufficient time has elapsed to demonstrate poor callus formation.

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EXPERIENCES WITH INTRAMEDULLARY FIXATION IN KNEE FUSION

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THE intramedullary fixation principle has been accepted in the treatment of certain fractures. It is natural, then, that the inquiry should be made to determine its usefulness in other conditions. Chopchal[1] reported seven instances in six patients in which he used this method. The conditions were paralysis of the limbs following poliomyelitis, two; rheumatoid arthritis, three; fibrosis ankylosis with flexion deformity, two. A review of his work suggested that the method was a practical one, offered the patient many advantages so far as postoperative comfort and ambulation were concerned, and seemed to involve no unwarranted risk in either the early or late postoperative period. In this discussion of indications and contraindications he made the statement, "Of course intramedullary pinning of the knee is not possible in cases of inflammatory diseases of the joint where arthrodesis is indicated. Here another technic has to be employed."

Our first application of the method three years ago was in the fusion of a joint, painful and greatly impaired in function by a valgus deformity and instability. This came about over a period of years and a number of traumas causing the joint to be of no use. The second instance, shortly after, was the fusion of a knee with severe hypertrophic changes. Ten years before this knee had been subjected to a joint débridement and it was serviceable for about eight years, after which gradual recurrence of pain, limited motion and instability appeared. The postoperative course of these two patients after intramedullary fixation was so smooth and relatively short that we were convinced of the merit of the method.

During this period we had on the service an adult female with tuberculosis of the right hip. In the course of a Brittain ischeofemoral arthrodesis a large tuberculous abscess lying in the distended inferior portion of the joint was entered at the time of osteotomy. The osteotomy site was flooded with pus and the open end of the medullary canal of the femur was exposed. Aspiration and cleaning of the area were done but probably imperfectly from the bacteriologic standpoint. The operation was continued, the opening in the ischeum made, and a suitable tibial graft taken and driven across in the usual manner. The wound in the region of the hip and that of the lower leg healed by primary intention. The bone transplant was successful and the patient went on to firm fusion without complications. All this was done under a heavy cover of penicillin and streptomycin, to which she showed no untoward reaction. This instance corroborates in a small way the numerous papers that have appeared in recent literature stressing the point that streptomycin has brought about a new era in the management of skeletal tuberculosis. It has been accepted that with the use of this drug in adequate dosage and over the proper period of time, we are able to subject these patients to surgical procedures much earlier than in the past, and we are justified in using surgical measures that have been rejected as carrying unwarranted risk in the days before antibiotics were available. (Fig. 1.)

The Küntscher nail was used for intramedullary fixation in tuberculosis of the knee in six cases (Table 1): two cases in which the disease was primarily synovial with early bone invasion and no contractures; two cases in which both synovial and osseous involvement were present with contractures of 45 to 60 degrees; and two with synovial and osseous change but no contractures, as they had been previously treated by traction and plaster fixation for rather long periods of time. All the wounds in this tuberculosis group healed uneventfully and in average time, and in each instance the knee went on to solid fusion. When the patient's general condition warranted, as judged by the temperature, body weight and sedimentation rate, a light cylinder cast was applied from the upper thigh to the ankle, and

FIG. 1. A. W., typical case of tuberculosis of the knee with external rotation deformity; later fused by the intermedullary nail method.

FIG. 2. H. W., typical of the cases in the Charcot series.

weight-bearing was permitted with crutches or cane aid as the patient desired.

In the hypertrophic arthritic group (Table II) no wound complications were met and it was possible for them to be ambulatory somewhat sooner than those with tuberculosis. In the Charcot group (Table III) the postoperative ambulation time of the patients depended mostly on the intensity of nervous system involvement. Those without a tabetic gait and no other joint involvement did about as well as the hypertrophic patients, while those with advanced cord changes or with other unstable joints were relatively slow. (Fig. 2.)

The operation is done through a long median parapatellar incision extending from just below the middle of the thigh to the tibial tubercle. We have not used a pneumatic cuff on the thigh because the bulk of the cuff prevents depression of the upper end of the Küntscher nail when one attempts to insert it through the trap door of the femur in as near a parallel course to the femur as possible. A less bulky hemostatic device such as the Esmarck or Martin bandage could probably be used. After the knee is open, the patella is excised and a synovectomy is done if indicated. We usually did this in the tuberculous and Charcot joints but not in the hypertrophic joints. The knee is then flexed sharply and the joint surfaces are resected and fitted.

TABLE I
TUBERCULOSIS OF THE KNEE

Name	Sex, Race, Age	Side	Type	Deformity	Wound Healing	Fusion Time (mo.)	Complications
M. W.*	M, W, 51	Right	Osseous and synovial	45° flexion contracture	Primary	8	Fracture of tibia at distal end of pin
J. G.	M, W, 21	Right	Same	None	Primary	4	None
M. L.†	M, W, 43	Left	Same	30° flexion contracture	Primary	7	None
H. S.‡	M, C, 32	Left	Same	None	Primary	6	Drained from sinus not associated with wound three months postoperatively
A. W.§	F, C, 56	Right	Same	90° rotation contracture	Primary	5	None
E. Q.§	M, W, 56	Right	Same	60° flexion contracture	Primary	6	None

* Fracture healed in normal time; it was caused by pressure of the pin against the anterior cortex. The tibia was very porotic from long disuse.

† Also had clinical tuberculosis of lungs, spine and tendon sheaths of right wrist; died one year after the operation of miliary disease.

‡ Also had tuberculosis of right shoulder.

§ Under treatment for pulmonary lesion.

TABLE II
ARTHRITIS OF THE KNEE

Name	Sex, Race, Age	Side	Type	Symptoms	Wound Healing	Fusion Time (mo.)	Complications
H. C.*	M, W, 44	Left	Traumatic	Pain, quadriceps weakness, valgus deformity	Primary	5	Transient peroneal nerve palsy
S. P.	M, W, 33	Right	Rheumatoid	15° contracture limited flexion, pain	Primary	3	None
W. T.	M, W, 61	Right	Hypertrophic	Pain, 10° contracture	Primary	5	None
T. B.	M, W, 51	Left	Traumatic	Pain, limited motion, drainage from sinus tract	Primary	6	None
C. H.†	M, W, 63	Left	Old fracture patella with infected repair and nonunion	Drainage, pain, limited motion	Drainage continued but no extrusion took place	6	None
L. H.	F, C, 57	Right		Swelling, pain, weakness	Primary	8	None

* Nerve recovery at time fusion was complete.

† Died nine months after operation of carcinoma of the bladder; two additional cases since chart was compiled.

3A 3B 3C

FIG. 3. H. C., after resection of the joint, excision of the patella and trimming of the condyles; note the passage of the nail through the posterior part of the intercondylar notch and posterior displacement of the tibia to meet it. A, x-ray taken in the operating room; B and C, after fusion and removal of the nail. In upper (C) note that the trap door in the femur is still visible.

The proximal opening of the tibial medullary canal is then identified. A suitable rectangular opening is then made in the anterior surface of the femoral shaft, large enough to admit the pin and to allow the proximal end to be depressed. The entire extremity is then adducted to get more clearance at the upper end of the pin and passage through the femur is started. When the pin appears at the intracondylar notch, the tibial opening is placed opposite and the driving is continued far into the tibial medullary cavity. (Fig. 3.) While this is being done, counter pressure is made against the foot and attention is paid to the rotatory alinement. The anterior portions of the condyles are then trimmed and this cancellous bone is packed into any surface inequalities about the resected joint. The wound is closed in layers and a pres-

TABLE III
CHARCOT KNEE

Name	Sex, Race, Age	Side	Wound Healing	Fusion ?	Complications
H. W.	M, C, 48	Left	Primary	No	Pin wandered distally and joint disrupted seven months after operation; amputation was done and wound dehiscence made secondary closure necessary
I. M.	F, C, 46	Right	Primary	No	Fracture of the nail at joint level four months postoperatively; new and longer nail inserted which also fractured three months after insertion
R. H.	M, W, 63	Left	Primary	Yes	Fracture of femur at site of trap door; fracture healed as knee was fusing
P. L.	F, W, 64	Left	Primary	No	None
A. K.	F, W, 67	Right	Primary	No	None
B. M.	M, C, 48	Right	Primary	No	None
F. V.	M, W, 68	Right	Primary	Possibly	None
G. M.	M, C, 54	Right	Primary	Too early	None up to time of writing

sure dressing applied. A heavy posterior mold of plaster during the immediate postoperative period and a walking cylinder from the upper thigh to the ankle is used after the wound is healed and the sutures removed.

If the knee is to be fused in full extension, as seemed particularly desirable in the Charcot group of cases, the nail will emerge at the intracondylar notch of the femur somewhat posterior to the central point. This is due to the fact that one cannot depress the pin at its upper end sufficiently to cause it to be actually parallel with the femur, because of the interposition of the soft parts of the anterior thigh. With the nail emerging posteriorly, it will be necessary to displace the tibia somewhat posteriorly in order to bring the opening of the medullary canal of the tibia opposite the end of the pin. This position causes the femoral condyles to be unduly prominent anteriorly and this is one reason we have trimmed these down and removed the patella. We see no objection to the use of the cancellous bone of the condyles if free of disease as material to aid in the development of fusion. It is admitted that this procedure nar-

FIG. 4. I. M., fracture of the nail while walking in a cylinder cast; it was removed and another nail inserted.

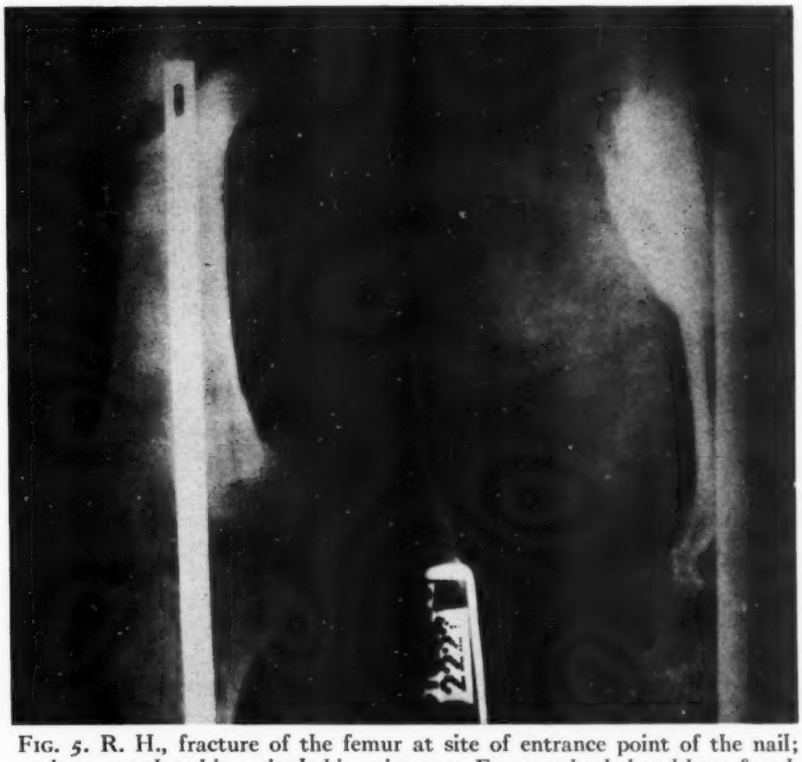

FIG. 5. R. H., fracture of the femur at site of entrance point of the nail; patient was placed in a single hip spica cast. Fracture healed and knee fused.

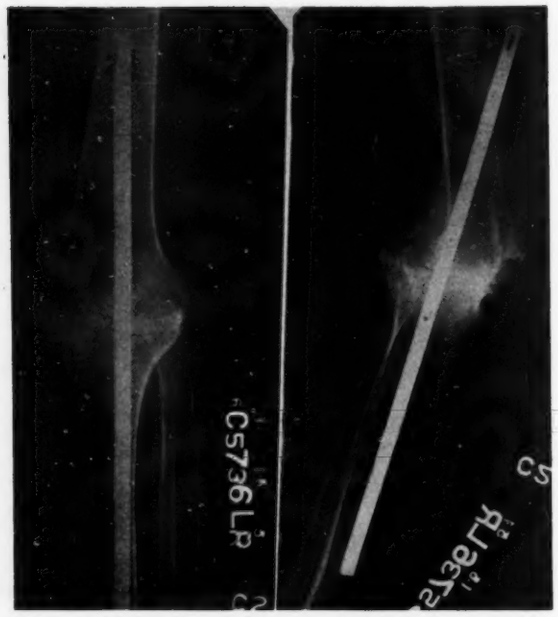

FIG. 6. Shows the tendency of the nail to wander proximally; in no instance did a nail wander distally.

rows the weight-bearing surfaces of the fused knee. Whether this has any significance in regard to future fracture complications remains to be seen. When the knee is fused in the optimum position of functional flexion, the insertion of the pin is much easier, the trap door in the femur is more distal and the surfaces do not have to be narrowed as much as in the other instances. Küntscher[2] suggests the use of a long nail (65 cm.) for the average thigh, driven from the femoral trochanter all the way through the femur and then across the knee into the tibia. This obviates the opening in the femoral shaft and has the advantage of not weakening the femur at the point of nail entrance in the lower third. However, the method can be used only if the knee is to be ankylosed in complete extension, and in many instances this position is not desirable. We have used three types of pin, the cylindrical curtain rod type with a longitudinal slit for the guide, the diamond shape and the clover leaf type. We believe there is no choice among them for this particular work. (Figs. 4 to 7.)

In conclusion, the method described utilizes the impaction principle which is desirable in arthrodesis because it permits early weight-bearing with light cast protection and with complete freedom of motion in all but the affected joint. The time required for solid bony fusion compares favorably with other methods.

FIG. 7. The nail lies in the interosseous space instead of the medullary canal of the tibia. No nerve or vascular complications occurred and it was allowed to remain until fusion of the knee was complete. It was then withdrawn through a small incision of the soft tissue at the distal end.

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DISCUSSION OF PAPERS BY DRS. SMITH, CAROTHERS AND LYONS, QUIGLEY, PEDERSEN AND DAY, AND STACK

CHARLES S. VENABLE (San Antonio, Tex.): I want to comment on the report that Dr. Pedersen made on the subject of sliding grafts in fracture of the tibia, which I believe has been a forgotten child too long. I think it is one of the most important

factors, particularly in tibial fractures, if there has been a delay, if there is a period when we have a delayed union, to get some fresh bone. I think a sliding graft is one of the best answers we have ever had, provided we follow the precedent that is offered today by Dr. Pedersen in using a large enough sliding graft, to take all the weight-bearing and all the resistance necessary during the period of healing.

I would like to make the comment that a properly sized sliding graft is a most valuable adjunct. It does not need hardware. Very often there may be a screw above or below, but for goodness sake, follow the doctor's precept and make them large enough.

Apropos of fractures of the os calcis, we overlook the tension on the posterior segment at the attachment of the tendo-Achilles and the strong muscles of the calf of the leg. We waste a lot of time trying to manipulate and nail together or screw together and fix these fractures with the continued tension of the tendon of Achilles. I found a long time ago that if I would simply divide the tendo-Achilles by a Z incision (it will grow together again), you can then control the fractures of the os calcis, particularly in its posterior segment without resistance, and you do not have so much hardware in the foot, and little, if any, permanent disability.

Barbara Stimson (Poughkeepsie, N. Y.): When Dr. Quigley asked me to discuss his paper, I do not think he knew that I had the privilege of wearing a walking cast for about four weeks last summer for fractures of the metatarsals. I would like to say I agree with him wholeheartedly. I have had similar very bad results from allowing plated or screwed tibias to walk in a walking iron, although they seemed to be firmly fixed, and I think one of the great problems he has brought out is the tendency for all patients in a walking cast to rotate the foot outward.

I think all of you who have used walking casts have been interested in the ingenuity of your patients in trying to cover their toes. Whether they wear ski-boots or a stocking or stockinette, they would like to have something to cover the toes. I was in the same situation. You want to protect your toes from being bumped as you walk around. I was going on vacation in Maine and I wanted to get out in the woods and I wanted to cover the rocks and pick blueberries. However, I did not quite see how I was going to do it.

So I stopped at a friend's moccasin shop on my way to Maine and, between us, we devised a moccasin-type toe to fit on the end of a walking boot. I have tried it out on my patients and have found that it makes a great deal of difference in the way they walk. Their toes are protected and they are not afraid, therefore, to do the heel-toe walk which they should do.

Incidentally, the women patients like it very much because it is not a bad-looking shoe type. This is one that will fit any type of boot and either leg. It helps prevent this rotation walk, as I say, and I speak feelingly because I have tried it.

Kellogg Speed (Chicago, Ill.): The Canadians have contributed importantly to the treatment of fractures of the calcaneus. I need only mention Fraser Gurd, Sr., who believed that the fractured foot should be encased in a shoe, not always plaster of Paris, as soon as possible, and weight-bearing should be inaugurated at once for the full amount, subliminal to unbearable pain, with no effort at reduction of any kind.

Wilson's fracture oration before the American College of Surgeons some years ago reviewed this whole subject very well, and Gallie's bone grafting operation for squash fractures with painful subastragalar joint is known to all of us. Finally, Harris' monumental work on the foot, including fractured os calcis, was based on the recent study of recruits taken in the Canadian Army during World War II.

The results after any treatment of fractures of the calcaneus may be interpreted from two standpoints: (1) the functional return of the use of the foot based mainly on the freedom from pain and the ability to wear an ordinary make shoe, with a wage-earning activity involved and (2) the cosmetic result, including the swelling and general appearance along with some sort of acceptable x-ray examination so often required as a measure of cure in settling the compensation cases in the courts of many states in the United States instead of the results of the clinical examination of the functional return and the ability to work which Dr. Carothers cared to stress.

In looking at the shape of the calcaneus, you cannot help but believe how impossible it is, once fractured, to mold or weld it into normal former shape; yet there are certain orthodox lines of treatment that may be required. In a case of an avulsion fracture and tearing off of the posterior portion, it is doubtful whether you could get away with a large fragment pulled off and a gross deformity without some form of operative procedure.

The os calcis is restored to normal shape by a very simple method, namely, passing a bone transplant through both fragments for fixation. Also in the complete crush fracture, with the distortion of the subastragalar and other joints and the loose fragments in the heel, we have terrific problems. That is what leads to the pain. In the old orthodox form, you and the general practitioner may attempt to mold them into shape and yet the patient will often end up with a distortion and thickening, giving a painful pressure under the malleolus.

I do not believe too much value lies in the tuber angle. I do not adopt that as a criterion at all, but the spreading of the bone and the pressure under

the malleoli can be seen. That distortion is really very worth while attempting to correct.

In the distortion, in the broken heel as compared with the normal, we see why we get that pressure. In some cases I have thinned that down by an operation, making the calcaneus appear almost like the normal, and thus relieving some of the symptoms. In the chronic painful subastragalar joint following a healing of a compression fracture in which there has been no manipulation and perhaps the wearing of no support at any time and too early weight-bearing, if it is a severe fracture, we may adapt Gallie's method by inserting a transplant through the talus in this direction directed forward. It does not have to go all the way through the subastragalar joint. After a few months, you get beginning union, filling in with bone, and the same heel four years later shows a complete fusion of the joint and relief of the pain from the weight-bearing.

ESLIE ASBURY (Cincinnati, O.): I think Dr. Carothers has given us a very common sense method of handling fractures of the os calcis. It is really a revolutionary return to first principles. We have wandered tremendously in the treatment of fractures of the os calcis and, although Dr. Carothers' method is unorthodox, it certainly has worked out. I have seen a number of these cases and I know the results are good. I have also used the method myself, with far better results than with the usual orthodox methods that we have been in the habit of using in the last ten or fifteen years.

I think Dr. Quigley's article illustrates we should never use walking casts in fractures of the os calcis until after about five weeks. I think in my use of walking casts in these cases, the results have been very bad, and I believe Dr. Quigley showed us the reason.

I think Dr. Stack's paper, in which he described a case of successful fusion of a Charcot joint, proved that we must be very careful about weight-bearing with our mechanical internal fixation gadgets.

As to sliding grafts, in thirty years' use of no other method in the treatment of these cases, that is to say of non-union of the lower third of the tibia, I have never seen it necessary to use internal fixation. I have never seen but two initial failures, and both of them obtained union with second operation.

J. HUBER WAGNER (Pittsburgh, Pa.): I think I would be remiss if I did not say that I enjoyed the excellency of all of these papers, and the paper of Dr. Quigley is timely. It is something I think we can all take home, give it a little more thought, and probably a little propagandizing among some of our younger colleagues who love to get their patients up the next day on a walking splint, regardless.

My primary purpose now, however, is to bring to your attention that the essayists today, in discussing their cases, used the terms simple and compound fractures. As you know, there was adopted by the Fracture Committee of the American College about 1948 a resolution attempting to give up the terms simple and compound for more distinctive and descriptive words, namely, open and closed fractures, when referring to what we used to call simple and compound. The purpose was that we would use these terms following, I believe, the English custom

I am sure the essayists are aware of the fact that this movement is afoot and it has been augmented by the American Orthopedic Association. I believe that in the future this society should give full support to the adoption of that terminology and the discussants or the essayists in the future should be careful about this nomenclature. We should attempt to keep up with modern usage.

FRASER N. GURD (Montreal, Can.); There was one feature of Dr. Quigley's paper that I do not want to let go unmentioned. Early protected weight-bearing rather runs in my family and the implication might be taken from his paper, although I am sure it was not his intention, that in ankle joint fractures the walking cast below knee was very often bad treatment. I agree about the tibia and fibula and about the os calcis, provided ordinary judgment is used. However, in the ankle joint fractures, my one plea is not to forget the mechanism of reduction of the fracture, even weeks later.

Manifestly, if an external rotation fracture is put up in a walking cast in anything for forced internal rotation, it will slip. Similarly, if a fibular flexion fracture is put up without pushing the foot into tibial flexion at the last moment before the plaster dries, it, too, will slip when these torsion forces which he mentioned come into play. Again, in the tibial flexion fracture the original mechanism must be remembered and must be overcorrected at the time that the walking cast is put on, be it perhaps weeks later.

I am not advocating that patients be up walking for a bimalleolar fracture the next day, but I do believe that, after experience has shown that sufficient gluing of the fragments has occurred to make weight-bearing safe, provided these precautions of correction of the original mechanism are taken at the time the cast is applied, the ultimate end result is very much better if the stimulus of weight-bearing is applied as early as possible to the bones and soft tissues about the ankle joint.

HENRY C. MARBLE (Boston, Mass.): I think Dr. Smith's presentation makes it abundantly

clear that he joins us in his dissatisfaction in the matter of intervertebral discs. We are dissatisfied (1) with the etiology or that conception of the etiology as to whether it is degenerative disease or whether it is the result of a single trauma; (2) with the diagnosis and all the factors being put together to make the diagnosis; (3) with the method, the indications for or against surgical operation, for or against conservative procedure, and (4) with the results.

We are evaluating these end results. Dr. Aitken has written one paper, and I have also collaborated in a paper studying the end results. I might say for myself that I have never operated on an intervertebral disc and I never will. They say the best umpire is the man who never played baseball; therefore, perhaps the best man to evaluate these cases would be the man who never did one.

We must have the evaluation medical and not legal. When legal gentlemen get into medicine, they make exactly the same mess of medicine that doctors do when they try to get into law.

Hasn't the time come for us to evaluate these things on a purely medical basis and to let the legal side of it drop by the wayside? I must confess that I do not understand an evaluation which is based upon a comparison of the loss of use of the arm for a disc which is in the lumbar spine. That is the legal side of it.

I think that one of the things which a society such as this might, with profit, do is to form a committee or to form some unit which could standardize such a very valuable, such a very necessary study as this. In this way we are all talking the same language, using the same methods, the same means, and the same yardstick of evaluation so that in the end we could say, in a medical way, what we believe is the proper procedure both as to the etiology, diagnosis, procedure and evaluation of end results.

Carlo Scuderi (Chicago, Ill.): I would like to say a few words about Dr. Stack's paper. It has been an excellent presentation. I have had the opportunity of seeing some of these films at the County Hospital and he has taught me two very valuable points. One is that this type of arthrodesis is excellent. If you have adequate exposure, you can certainly get a good reapposition of the arthrodesing surfaces and you can keep them in contact. You also can get these people up and about much earlier without weight-bearing and practically no pain once the wound is healed.

The second thing that I learned from him was exemplified in the case in which the pin did not go where the surgeon thought it was going. In the two cases that we have done we have learned to spend a little time taking the anteroposterior and lateral x-ray film in the operating room, before closing that wound up, to be sure the pin is in the medullary canal.

I do not like to disagree with an older man; but if I understood what Dr. Venable said, I want to voice one very strong objection. I heartily disapprove of the complete section of the tendon of Achilles to treat a fracture of the os calcis. We have other methods of positional relaxation of the tendon of Achilles that may not be as complete as a complete section of the tendon surgically, but in the few cases I have tried to repair of acute laceration of the tendon of Achilles, I believe it is better if we do not do it surgically, as this produces an additional serious source of disability. Whether or not Dr. Venable may have meant partial section, I do not know; but if he meant complete section of the tendon of Achilles, I want heartily to disagree with him.

Thomas B. Quigley (closing): There is no basic disagreement, I think, between the essay and Dr. Gurd's remarks. What I was trying to say in perhaps a roundabout fashion is that there is no substitute for surgical judgment in the treatment of fractures below the knee. The name Gurd, as we all know, has been associated with surgical judgment in large measure for very many years.

Ralph G. Carothers (closing): I would like to point out just one thing which I may not have stressed, and that is that we must forget these lateral views and these angles of Baylor and get down to what we see in the anteroposterior view in other words, what has happened to the bone laterally. I have had the experience of allowing a patient to have no treatment when the os calcis on one side was very bad and the os calcis on the other side was apparently very slightly injured. That compression from side to side, I think, is necessary.

DISLOCATIONS OF THE OS COXAE

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Galveston, Texas

THE os coxae or hip bone, the largest of the flat bones of the skeleton, consists of three parts, namely, the os ilium, os ischium and os pubis. The three bony units are primarily distinct but fuse together in the process of growth to form the irregular bone.

The right and left os coxae articulate with each other anteriorly and with the sacrum posteriorly to form the pelvis.

The two os coxae articulate with each other anteriorly at the symphysis pubis which joint is of the general plan of an amphiarthrosis. (Fig. 1.) The joint has very limited movement, is united by ligaments and an interposed disc of fibrocartilage in the interior of which is an incomplete joint. This joint cavity may be lined by synovial membrane and a plate of hyaline cartilage covers each of the opposing surfaces of the bones concerned.

The ligaments of the symphysis os pubis are four. The anterior pubic ligament is quite thick and strong. (Fig. 2.) The posterior and superior ligaments are weak and offer little support. (Fig. 3.) The arcuate or inferior ligament has considerable vertical thickness and strength.

The sacro-iliac joint is a diarthrosis, the joint cavity of which may be crossed by fibrous bands. (Fig. 4.) The osseous surfaces are completely covered with hyaline articular cartilage and permit a limited gliding motion.

The cavum articulare is surrounded by ligaments of varying thickness and strength. The anterior part of the capsule (anterior sacro-iliac ligament) is thin (Fig. 5) and much weaker than the posterior portion (Fig. 6) which consists of three ligaments, namely, the long posterior sacro-iliac, short posterior sacro-iliac and the interosseous.

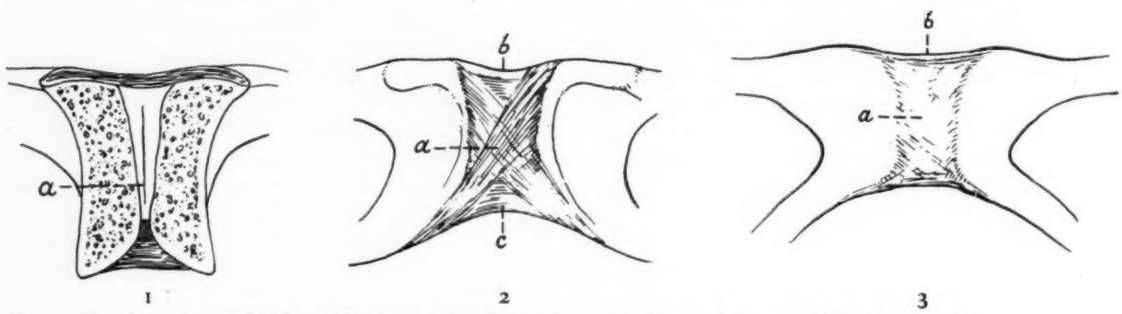


FIG. 1. Section of symphysis pubis showing rudimentary articular cavity; *a*, rudimentary cavity.
FIG. 2. Anterior view of symphysis pubis showing decussation of the fibers of the anterior ligaments; *a*, anterior ligaments; *b*, superior ligament; *c*, inferior ligament.
FIG. 3. Posterior view of symphysis pubis; *a*, posterior ligaments; *b*, superior ligament.

The long posterior sacro-iliac ligament is a superficial portion of the interosseous ligament and passes from the posterior superior iliac spine to the third or fourth sacral segments. The long posterior and the interosseous ligaments bear the greatest responsibility for suspending the sacrum and weight of the trunk from the hip bones. The short posterior sacro-iliac ligament is of secondary importance. Several accessory ligaments associated with but not a part of the sacro-iliac joints are the iliolumbar, sacrotuberous and sacrospinous. These posterior ligaments stabilize the sacrum and the last lumbar vertebra, tuberosity of the ischium and ischial spine, respectively.

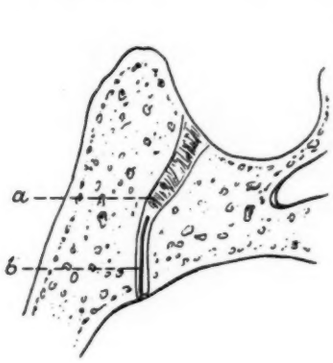
The sacro-iliac joint has a comparatively small joint surface (Fig. 7) and the adjacent ligamentous attachments are not as strong or secure as would be expected for the service required. Anteriorly, the joint is weakly supported; posteriorly, there is greater strength braced by three adjacent ligamentous structures. This mechanical arrangement allows the joint to be vulnerable to hyperabduction

and hyperadduction forces which are, however, restricted anteriorly by the symphysis pubis. (Fig. 8.)

The symphysis pubis and sacro-iliac joint present least stability to hyperextension and hyperflexion movements. Hyperflexion of the os coxae seldom, if ever, disrupts the joint because it is difficult to transmit this force to the joint by femoral fixation and also the three accessory posterior ligaments stabilize the sacro-iliac joint against such motion. Hyperextension of the os coxae is resisted by the weak anterior sacro-iliac joints and the ligaments of the symphysis pubis. The application of the hyperextension forces to the os coxae can be transmitted by means of the femur locked in abduction or adduction by the iliofemoral ligament and the musculature. Thus it is possible to rotate the entire os coxae in hyperextension by a force applied to the locked femur and stabilized trunk or a fixed femur with forced hyperextension of the trunk. This movement will disrupt the symphysis pubis and sacro-iliac joints in a sagittal plane resulting in the dislocation of the os coxae.

The additional forces combined with the hyperextension are medial and lateral rotation. Therefore, the displaced position of the os coxae will be in medial or lateral rotation after cessation of the combined forces of hyperextension and rotation.

The muscles of the thigh during trauma of this type become voluntarily or reflexly fixed and thus contribute to making the hindquarter a mechanical entity. The iliopsoas splints the pelvis anteriorly and is so placed to limit hyperextension; but when the movement is once started, the leverage is soon lost to prevent the extreme degree to which the hyperextension must progress.



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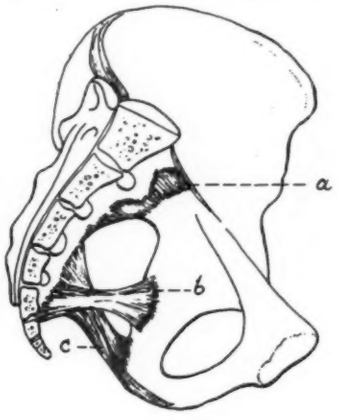

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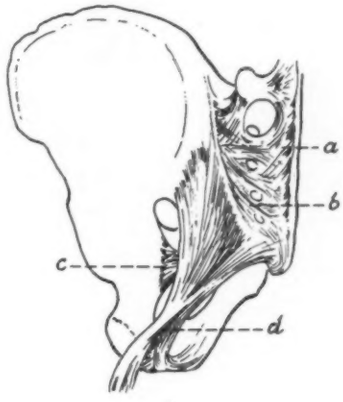

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FIG. 4. Frontal section through sacro-iliac joint; *a*, interosseous ligament; *b*, joint cavity.

FIG. 5. Medial sagittal section of pelvis showing ligament; *a*, anterior sacro-iliac ligament; *b*, sacrospinous ligament; *c*, sacrotuberous ligament.

FIG. 6. Posterior view of sacro-iliac and accessory ligament; *a*, short posterior sacro-iliac ligament; *b*, long posterior sacro-iliac ligament; *c*, sacrospinous ligament; *d*, sacrotuberous ligament.

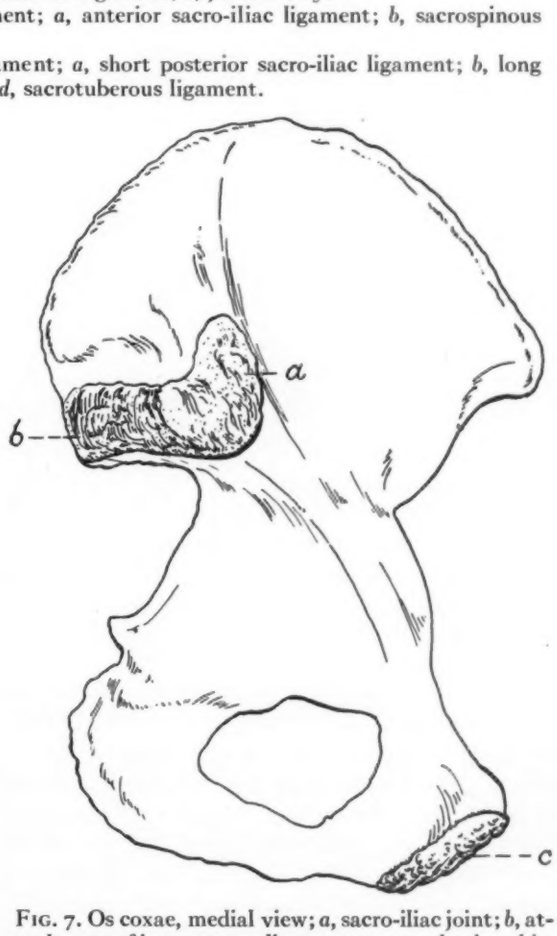
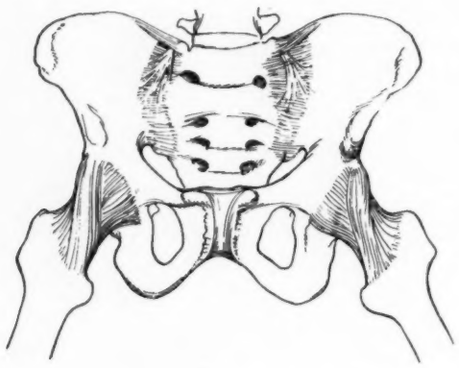


FIG. 7. Os coxae, medial view; *a*, sacro-iliac joint; *b*, attachment of interosseous ligament; *c*, symphysis pubis.

The observation of Taylor[2] and others in these cases show an absence of external trauma to the pelvic area. Fractured femoral necks have been recorded on the dislocated side which add to the hyperextension and hyperabduction explanations of the dislocation.

location. Dislocations of these joints when seen with fractures result from a combination of hyperextension and compression forces. The problem of the multiple fractures with or without dislocation is in a different category.

Dislocations of the os coxae vary in degree



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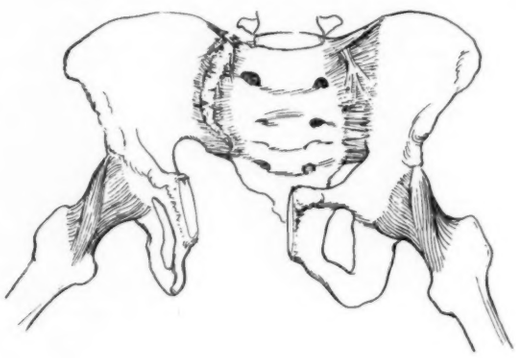

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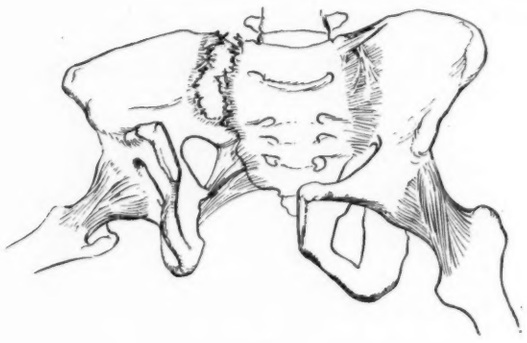
FIG. 8. Normal pelvis showing relationship of sacro-iliac and symphysis pubis ligaments.
FIG. 9. Hyperabduction type of dislocation; femur in extension.



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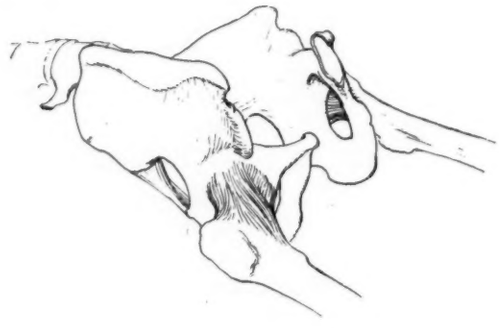

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FIG. 10. Hyperabduction type of dislocation; femur flexed 90 degrees with the trunk.
FIG. 11. Hyperextension rotation of the os coxae in the sagittal plane.

Hyperflexion of the os coxae, because of the absence of a femoral lever, is not practically possible, but if it were executed, it would be resisted by the accessory ligaments as well as the strong posterior sacro-iliac ligament. There is no clinical evidence to support a dislocation of the os coxae by hyperflexion although it is theoretically a possibility.

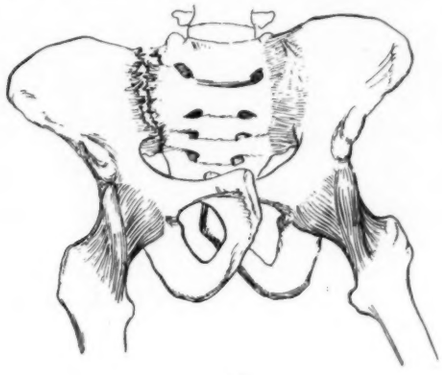
Dislocation of the pelvic bone is not usually associated with major fractures of the pubic rami, wing of the ilium or any part of the ischium. Small fragments torn by the ligaments from the sacral or pubic articular surfaces are frequent. The anteroposterior forces which compress and fracture the pelvis or the lateral forces, which accomplish the same, do not usually present sacro-iliac symphysis pubis dislocation from minimal displacement to massive hindquarter distortion. The problem of incomplete dislocation offers no great problem because no manipulative treatment is necessary and rest in bed is the solution of the difficulty.

The dislocations of the os coxae can be classified as the hyperabduction type and the hyperextension type. The dislocating forces are transmitted to the pelvis by the long leverage of the femur which locked in the acetabulum by its ligaments and splinted by the muscles cause hyperabduction or hyperextension. Abduction without lateral rotation or adduction without internal rotation is almost impossible. The application of all dislocating forces predicate fixation during trauma of the non-dislocated portion of the pelvis.

MECHANICS OF DISLOCATION

The hyperabduction type results when trauma is exerted on the femur locked in extension. (Fig. 9.) The force usually results from a fall which spreads the lower extremities in extreme abduction separating the symphysis pubis and sacro-iliac joint. It is also possible to transmit a rotary force when the femur is locked. The hyperabduction force continues to function until the pelvic joints separate, first the symphysis and then the sacro-iliac, and results in a wide separation of the symphysis pubis.

Hyperabduction and lateral rotation transmitted by the locked femur flexed to 90 degrees with the trunk (Fig. 10) produce a separation of the sacro-iliac and pubic joints by a rotary type of motion. The traumatic result in the locked femur in extension and the locked femur flexed to 90 degrees with trunk is identical.



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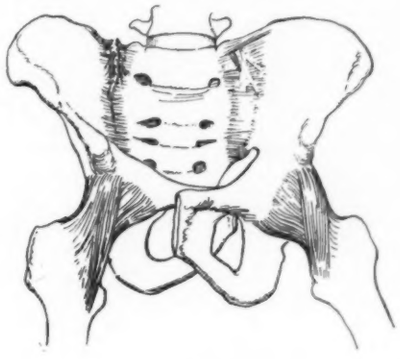

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FIG. 12. Hyperextension type with internal rotation; the dislocated os coxae is anterior to the non-dislocated os coxae.

FIG. 13. Hyperextension type with internal rotation; the dislocated os coxae is posterior to the non-dislocated os coxae.

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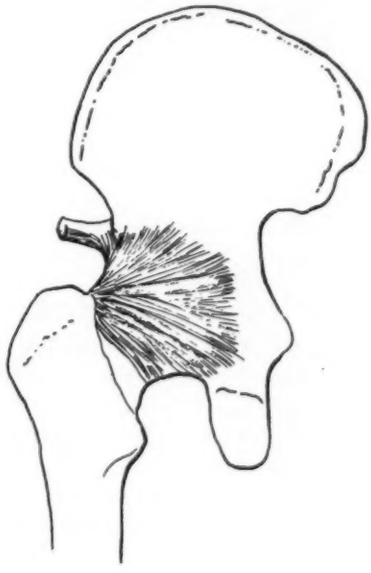

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FIG. 14. A, Anterior view of hip joint showing iliofemoral ligament; B, posterior view of hip joint showing ischiocapsular ligament.

When the hyperextension force occurs, the sacro-iliac and symphysis pubis ligaments are ruptured by rotary motion. (Fig. 11.) When such resistance is disrupted, the bone will rotate in the sagittal plane to the extreme traumatic position. As the distorting force is released, the parts will assume a position

FIG. 15. Hyperextension and medial rotation of the os coxae. Clinical position: lower extremity internally rotated, thigh and buttocks off table.

FIG. 16. Method of reduction: femur on uninjured side, knee flexed, thigh flexed to right angles with trunk, extremity laterally rotated to lock the femur and pelvis at hip joint.

dictated by the trauma. Thus the hyperextension type with lateral rotation and abduction will present a dislocated os coxae with a wide separation of the symphysis pubis and the affected lower extremity will be in lateral rotation.

The hyperextension type with adduction and internal rotation assumes two major positions. The position differential is determined by the relative position of the symphysis pubis. In the hyperextension adduction internal rotation type, after rupture of the joint ligaments and the traumatic force subsides, the displaced pelvic bone may occupy a position with the displaced symphysis anterior (Fig. 12) or posterior (Fig. 13) to the opposite symphysis. In either type the pelvic contents are subjected to great trauma by the displaced or the normal os coxae. Urethral and bladder injuries can be expected if the trauma caused marked pelvic migration of the displaced symphysis.

The explanation of the displaced os coxae being anterior or posterior at the symphysis pubis is rather complicated. When the hyperextension reaches maximum displacement and the pubic surfaces are no longer intact, reposition during flexion, internal rotation and adduction follow. Thus as the pelvic bone returns to position by its rotary motion in the sagittal plane, the symphysis occupies a position posterior to the unaffected symphysis. Sagittal rotation occurs while the os coxae is posteriorly and medially displaced. When it does take place, the bones become quite fixed in the distorted position.

It is also possible that by the subsiding of the hyperextension force the dislocated hindquarter is pushed anteriorly, and thus the displaced symphysis occupies a position anterior to the unaffected pubis.

The clinical position of the hyperextension adduction internal rotation type is the affected lower extremity cannot be placed flat on the table concurrently with the normal side when the patient is in a supine position, due to the internal rotation of the dislocated os coxae.

There have been no case reports of bilateral os coxae dislocations in the same person.

All dislocations of the os coxae are the result of great trauma. The patients suffer from severe shock and frequently complicating injuries in other corporal areas. The usual treatment for shock and such injuries must be instituted. Local dislocation frequently damages the pelvic structures and the usual complication affects the bladder and urethra. The urinary damage must be properly treated. The preferred care should be first, reduction of the dislocation and then attention to any soft tissue damage. Such treatment should be instituted as promptly after the trauma as possible. The reason for

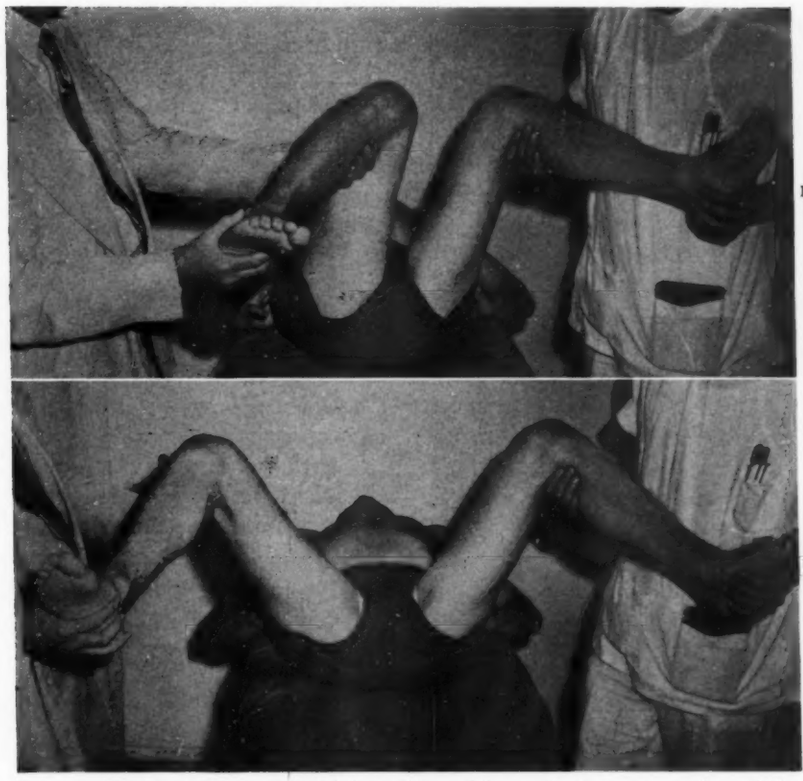

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FIG. 17. Flexion of knee and thigh, locking of femur by lateral rotation of the extremity on the affected side.
FIG. 18. The extremity of the injured side is then rotated laterally, rotating the os coxae from its locked position with the opposite side.

reduction before attempting bladder or urethral care is that these structures are greatly distorted in the unreduced dislocation, and proper repair is difficult or may even add trauma surgically. Damage to pelvic structures other than the urinary system are rare.

METHOD OF REDUCTION

Reduction of the dislocation of the os coxae is the application of forces in reverse which caused the luxation. General anaesthesia is preferred and necessary to reducing the luxation.

The hyperabduction type can be reduced and retained by pressure applied medially to the bone and internally rotating the pelvic half to its normal position. Retention of the reduction is maintained by a sling or cast. The reduction can also be accomplished by placing the patient on the uninjured side and allowing the weight of the hindquarter to reduce the deformity (Watson-Jones) and applying a cast to include both thighs and the trunk.

The hyperabduction and lateral rotation with the femur-flexed type of dislocation produces the same deformity as the hyperabduction type. The reduction and its maintenance in corrected position is accomplished in the same manner as the aforementioned.

Hyperextension with lateral rotation and abduction produces a traumatic displacement with a wide symphysis pubic separation similar to hyperabduction type as in Figure 9. The reduction can be obtained by medial rotation of the displaced os coxae and retention by a sling or cast.

The hyperextension and internal rotation type with the displaced pubis anterior can usually be reduced by applying pressure on the ilia and rotating the os coxae laterally. If the pubic bones become locked, the method of reduction must be as that applied in the next type of displacement.

The hyperextension and internal rotation type which has the displaced anterior pubic margin posterior to the normally placed pubis is probably the most difficult to reduce. This dislocation is usually so firmly fixed that the forces applied to the ilium and pubis will not

FIG. 19. Reduction completed with return of normal relationship of both lower extremities.

reduce the deformity. The use of the femur as a lever can be utilized to advantage. The femur is locked in flexion, abduction and lateral rotation utilizing the strong iliofemoral ligament (Fig. 14) to hold the femoral head firmly in the acetabulum and stabilize the trochanter against the acetabular margin.

The patient is placed in the supine position. (Fig. 15.) The knee is flexed, thigh flexed 90 degrees, abducted, and laterally rotated on the uninjured side to stabilize that portion of the pelvis by the hip joint and is held by an assistant. (Fig. 16.) When flexed on the unreduced side, the femur occupies an almost vertical position due to the medial rotation of the displaced bone. The knee is flexed, the femur flexed to 90 degrees, abducted, and laterally rotated and the hip joint locked on the dislocated bone. (Fig. 17.)

Gentle pressure is exerted against the medial side of the knee using the palm of the hand, the counter force maintained by the assistant holding the opposite lower extremity. (Fig. 18.) A rocking type of motion externally rotating the pelvis is produced rather than one strong effort, and the dislocated os coxae will gradually emerge from the pelvic cavity and then suddenly and usually audibly snap into reduction. (Fig. 19.)

POSTREDUCTION CARE

The after care of the uncomplicated hyperabduction cases and hyperextension cases is the pelvic sling or cast and immobilization for eight to twelve weeks. After reduction, the hyperex-

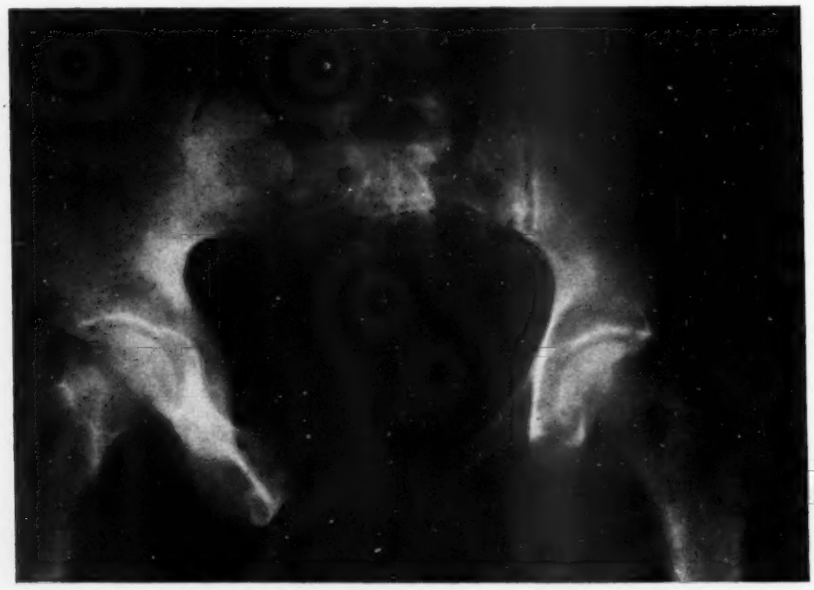

FIG. 20. Hyperabduction dislocation of os coxae with fracture of portion of sacrum in area of interosseous ligament; extensive urethral and bladder damage.

21A 21B

FIG. 21. A, Hyperextension dislocation of os coxae without fracture; displaced os coxae in medial rotation and posterior displacement; urethra ruptured. B, reduction by lateral rotation maneuver; six months' postreduction.

tension internal rotation group can be treated by recumbancy for a like period of time.

Following reduction of any type the x-ray must be carefully studied for any proximal migration of the dislocated bone. Another x-ray seven days after reduction is desirable because the abdominal and lumbar muscles may cause the os coxae to migrate silently upward, even though no displacement was evident in the x-ray immediately after injury.

When such complication occurs, the use of well-leg traction is desirable; or if the patient is in a pelvic splint, Russell traction should be used. However, the traction required is usually quite great to correct and maintain any upward displacement. Therefore, our experience has taught well-leg traction to be the most desirable and dependable. If an interval of displacement of the upward dislocation is longer than seven days, the reduction is difficult or impossible due to fibrosis of the affected areas.

Sequelae of dislocations of the os coxae are traumatic arthritis and urinary difficulties such as strictures, incontinence and damage to the sympathetic nerve supply to the penis. Fortunately, the dislocations have comparatively few other major complications.

Figures 20 and 21 are x-rays showing the hyperabduction and hyperextension types of dislocations.

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INTERNAL FIXATION OF FEMORAL NECK AND INTERTROCHANTERIC FRACTURES*

USE OF ANCHOR SACRAL REST AND GALLAGHER PROTRACTOR

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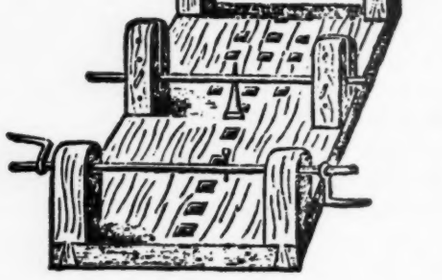
OVER 2,400 years ago Hippocrates, lineal descendent of the mythical Aesculapius, observed in his book on the articulations[1] that, "Any person who practices medicine in a populous city should have prepared a quadrangular board, scamnum or bathron, (meaning a bench that you sit or lie on) to facilitate the reduction of dislocations of the hip joint." His detailed description of the apparatus contains practically all the basic principles of the present day fracture table. Our modifications of the scamnum in this era are merely refinements, which sometimes adhere to and sometimes detract from the



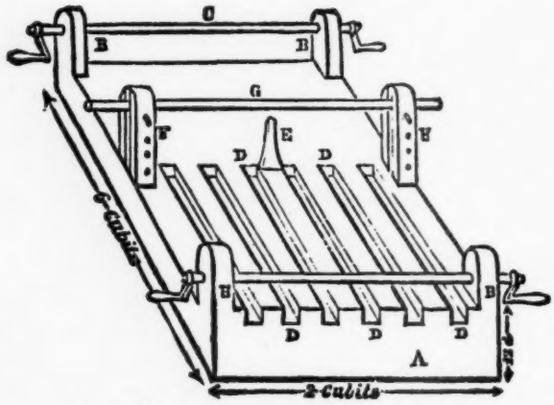


FIG. 1. Scamnum[2] Hippocrates.

* From the Jackson Clinic, Madison, Wis.

FIG. 2. Patient on Hawley table with sacral rest attachment.

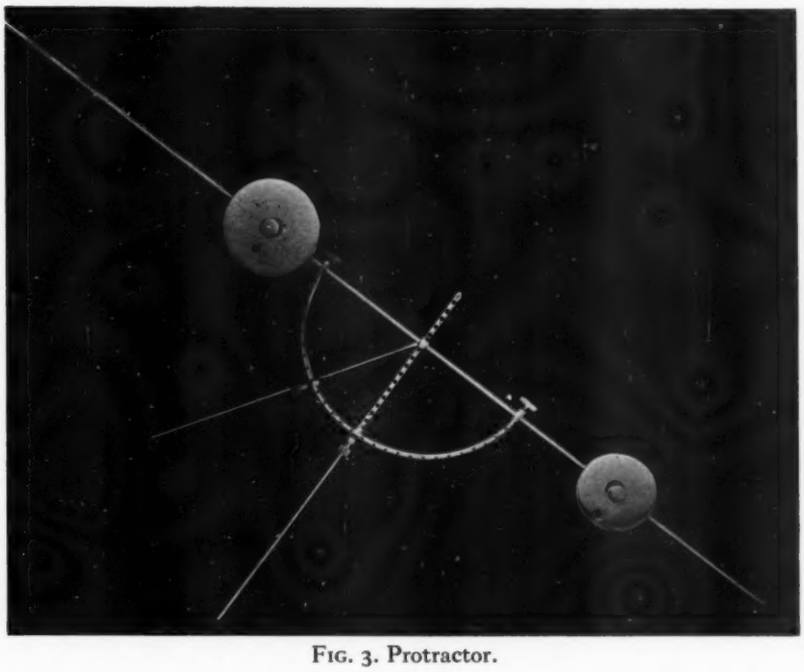


FIG. 3. Protractor.

unalterable basic principles of balanced traction and countertraction known in antiquity. (Fig. 1.)

For the past year we have been using the pelvic anchor sacral rest[3] in the operative fixation of fractures about the hip joint. The apparatus has several advantages heretofore not incorporated in any modern fracture table, namely, it is adaptable to patients of all sizes and ages from the cradle to the grave. It permits rigid fixation of the pelvis without undue pressure, and it allows unilateral leg traction in all directions by whatever method of reduction the operator chooses without disturbing the pelvis. It permits distribution of pressure from traction over a wide area reducing the number of pounds of pressure per square inch of skin surface to a minimum. With unilateral leg traction the well leg can be slung in any convenient position in muscle balance to accommodate the lateral portable x-ray equipment. It insures uniformly excellent

FIG. 4. Protractor overlay postreduction.

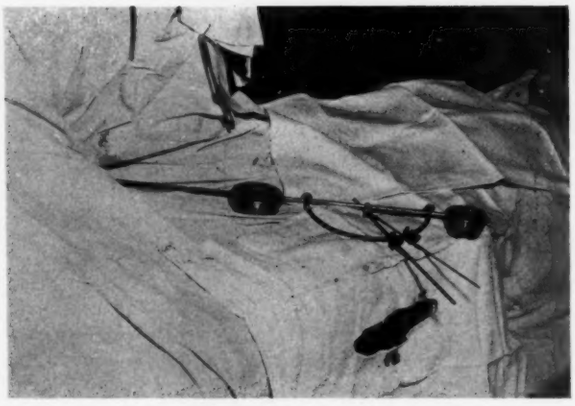


FIG. 5. Protractor sterile set-up during operation.

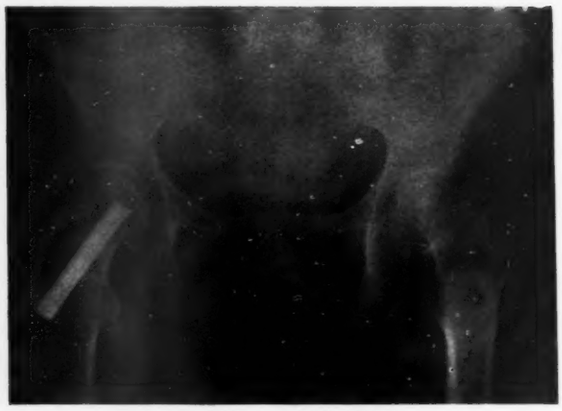


FIG. 6. Case 1. Original injury.

anteroposterior and lateral x-ray films with the least possible inconvenience to the operator and a pleasure to the technician who is unhampered in his work and is excluded from the operative field. The set-up opens the door for further improvements all of which do not occur to one individual. (Fig. 2.)

After employing the contrivance for the first time it occurred to us, in view of the fact that the head and neck of the femur always appeared centered on the anteroposterior film, that it should be a relatively simple matter to devise a protractor to attach to the upright posts of the sacral rest. Such a device would insure an accurate introduction of whatever fixative material is desired for the case at hand.

Accordingly, we had made a solid stainless steel instrument consisting of two tapered hemispheres and a protractor with multiple guide rods mounted on a cross beam that also serves as an accurate guide for the lateral x-ray equipment. All parts are adjustable and controlled by simple set screws. The circumference of the protractor is perforated at intervals of 5 degrees, and the central indicator rod perforated at ¼ inch intervals. The instrument is adaptable to either right or left hip by simply reversing the protractor on the cross beam. The protractor acts as an overlay on the anteroposterior x-ray film. It can be sterilized and is equally effective before and after draping the patient due to the weight of the hemispheric supports. (Figs. 3, 4 and 5.)

FIG. 7. Postreduction.

FIG. 8. Process of introducing Smith-Petersen nail with aid of protractor.

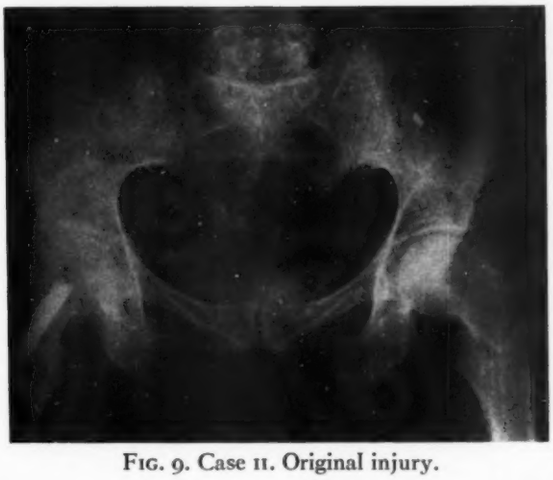


FIG. 9. Case II. Original injury.

The following case histories illustrate the use of the sacral rest and protractor in femoral neck and intertrochanteric fractures.

CASE REPORTS

CASE I. An eighty-six year old white female, No. 86-076, fell at home injuring her left hip. X-ray on May 19, 1951, revealed displaced subcapital fracture. Fixation was done with Smith-Petersen nail on May 23rd utilizing sacral rest and overlay protractor. The patient was discharged from the hospital on crutches with weight-relieving walking caliper on July 3rd. Progress is excellent to date. (Figs. 6, 7 and 8.)

CASE II. A sixty-four year old white female, No. 174-908, tripped and fell injuring her left hip on March 21, 1951. X-ray revealed intertrochanteric fracture left hip, open reduction with Moe plate and screw fixation, March 22nd. Postoperative convalescence was uneventful. The patient was discharged from the hospital on April 12th. Progress is satisfactory to date with fracture well healed in valgus by x-ray. (Figs. 9,10 and 11.)

FIG. 10. Postreduction.

FIG. 11. Process of applying Moe plate with aid of protractor.

CONCLUSION

Attention has been called to the benefits of the anchor sacral rest and an overlay protractor in the operative fixation of fractures about the hip joint. Again in the words of the great Hippocrates,[4] "The prime object of the physician in the whole art of medicine should be to cure that which is diseased and if this can be accomplished in various ways, the least troublesome should be selected."

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SUPRACONDYLAR FRACTURES OF THE FEMUR

A RECOMMENDED TREATMENT FOR NON-UNIONS AND FRESH FRACTURES

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SUPRACONDYLAR fractures of the femur are a real challenge to everyone who treats them because of the frequent difficulty one has in attaining adequate reduction and immobilization and because of the additional fact that considerable knee motion is permanently lost due to the required period of immobilization.

A method which permits accurate reduction and firm fixation of the fracture shortens the period of disability because of faster callus formation and also permits earlier mobilization of the knee, minimizing the ultimate loss of knee motion. The authors believe that the use of the blade plate in fresh cases offers these definite advantages. Only when a supracondylar fracture is in excellent position should conservative treatment such as traction or cast immobilization be used. Once displacement of some degree is present it is believed that a definite surgical indication exists.

Non-union of supracondylar fractures of the femur in recent years has been found to be common. In this series are three patients who were operated upon for non-union of the fracture within a period of three months.

Up to March 28, 1950, when the first patient was operated upon for a non-union (C. K.) using a massive bone graft and blade plate, innumerable other methods had been tried with indifferent results. The reduction was often inadequate, the period of immobilization long and the loss of knee motion great.

The gamut of skeletal traction, Roger Anderson pins with external bar fixation, bent knee in a spica cast, Russel traction, intermedullary autogenous bone grafts and intramedullary beef bone grafts were found to be successful in some cases, but the end results left one with much to be desired.

Perforation of the popliteal artery, although frequently referred to in textbooks, was found to occur only once in twenty-one years. The number of supracondylar fractures seen during this period could well be in dozens rather than in single digits.

PATHOLOGY

Supracondylar fractures of the femur do not necessarily follow any one definite pattern. The etiologic basis predetermines in many instances what the pathologic condition will be. As a rule, however, most of the cases are either transverse or short oblique fractures with the proximal end of the distal fragment rotating posteriorly. (Figs. 1 and 2.) The distal end of the proximal fragment invariably is displaced anteriorly under the quadriceps tendon or under the patella. Should this fragment have a sharp thin point, penetration into the quadriceps tendon or muscle frequently occurs and nothing except an open reduction will be successful in disengaging it.

Twisting injuries usually produce spiral fractures in this area, running up into the lower third of the femoral shaft (Figs. 3 and 4) while direct blows associated with considerable violence produce severe dicondylar fractures with separation of the condyles in addition to the rotation of the supracondylar fragments. This is often seen following automobile accidents in which the patient is thrown against the dashboard with the knee in the bent position. (Figs. 5 and 6.)

Associated injuries to the vessels and nerves do occur but are not a very frequent complication. Fractures of the patella are occasionally seen associated with supracondylar fractures but the association of the two in a single leg is most uncommon. Perhaps it is because a blow capable of fracturing the patella is not mechanically so to fracture the femur, and vice versa.

Non-unions of the supracondylar area have been found to be of two types. The most common type is that in which osteoporosis slowly increases in the fragments, the bone ends round off and the callus production mechanism remains dormant until a bone graft is inserted

1 2

FIG. 1. M. S., age seventy-eight. On May 19, 1951, this lady was attempting to step over a low wire fence when her heel caught and she fell, sustaining a supracondylar fracture of the femur. Because of her poor general condition, surgery was delayed ten days when an open reduction was performed. Because an additional dicondylar fracture existed, one screw was used to hold them together and a straightened blade plate was used for fixation of the femoral shaft to the condyles.

FIG. 2. Shows the condition of the fracture on September 4, 1951, three and one-half months after surgery; the hip spica cast was removed and knee motion was begun actively with physical therapy.

3 4

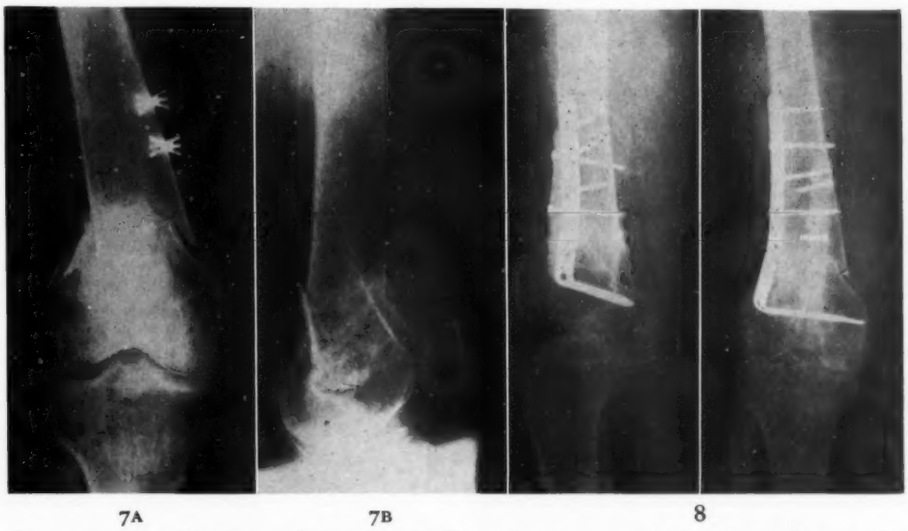
FIG. 3. J. T., age fifty-four. On August 1, 1951, this patient fell, sustaining a supracondylar fracture of the femur. He was operated upon five days later after a trial of skin traction. A blade plate was used for fixation. Because the distal fragment had a tendency to rotate slightly, leaving a ¼ inch gap between the two fragments, two screws were inserted from front to back for further fixation.

FIG. 4. Shows the progress of the case as of October 3, 1951, at which time callus formation is visible and the position of the fragments is excellent. After three weeks, active motion was begun with a Pearson attachment, followed by physical therapy.

into the area to stimulate callus formation. (Figs. 7 and 8.) The other type of non-union is sclerosing in type. An excessive amount of bone proliferation occurs with long osteophyte formations and very dense calcium deposits in this pseudocallus. For some unexplained reason the fracture line never completely disappears in spite of the fact that the bone radiographically is very much denser than the neighboring normal bone. At surgery this bone is found to be very hard to cut; and when pieces are chiseled off or the area drilled into, a substance

5A 5B 6A 6B

FIG. 5. A and B, J. W., age sixty-five. On October 15, 1950, this patient fell downstairs sustaining a supracondylar fracture of the femur with posterior rotation of the distal fragment which could not be rotated back into place by manipulation and traction. On November 2, 1950, the fracture was reduced by open operation and the reduction maintained by the use of a blade plate. Postoperatively the patient was treated in traction.
FIG. 6. A and B, show the condition of the fracture on May 3, 1951, six months following surgery, at which time the patient was walking without any form of external support.



7A 7B 8

FIG. 7. A and B, M. D., age forty-nine. On December 20, 1949, this patient fell on a sidewalk sustaining a supracondylar fracture of the femur. He was treated originally in skeletal traction and later in a cast with no evidence of union. After eighty days it was decided that bone growth would not occur without surgery. On May 4, 1950, this patient was operated upon and a massive tibial bone graft plus a blade plate was inserted.
FIG. 8. Shows the result on November 1, 1950, six months later, when gradual weight-bearing was permitted with the use of crutches.

that looks like chalk is encountered. The material is completely avascular as far as one can observe grossly at the operating table. (Figs. 9 and 10.)

It is not always easy either from a clinical or radiographic standpoint to determine whether or not a solid union is present in the presence of the sclerotic bone at the site of fracture. Case C. K. (Figs. 9 and 10) led us to believe that union was present until the fracture site began to bend when unprotected weight-bearing was permitted. In another case, that

9A 9B 10A 10B

FIG. 9. A and B, C. K., age thirty-five. On March 29, 1947, the patient was involved in an auto accident and refractured the femur at the site of a previous fracture sustained eight years before. Seven weeks later the case was referred to our attention and an open reduction was performed; internal fixation was attained by the use of three screws. After six months it was believed that a solid bony union existed, and weight-bearing was permitted. On October 27, 1949, it was found that the site of fracture was gradually bending and definite evidence of a sclerosing non-union was present. It was not until March 28, 1950, that the patient permitted further surgery, at which time a massive bone graft was inserted with a blade plate for additional fixation.

FIG. 10. A and B, show the condition of the fracture on April 20, 1951, thirteen months postoperatively. She had been walking with unprotected weight-bearing seven months following the last operation.

of a man sixty-two years of age, the sclerosing non-union never did obliterate the fracture line even though he has been followed up for more than four years. Judiciously or injudiciously this man today will not permit us to reoperate upon him for a massive bone graft to the area.

PROGNOSIS

One must accept some restriction of knee motion in every case of supracondylar fracture of the femur. However, by early anatomic reduction and early active and passive motion of the knee (four to six weeks postoperatively depending upon the pathologic condition) one can, in most instances, minimize the loss of function. This requires the cooperation of the patient and the intelligent use of physical therapy. In the average case of a middle-aged patient unprotected weight-bearing can rarely be attained safely in less than five to six months in fresh fractures, while in cases of non-union requiring bone grafting unprotected weight-bearing is rarely safe in less than six to eight months.

To date the authors have had no non-unions occur in fresh supracondylar fractures reduced and fixed surgically by the use of a blade plate. Seven fresh cases have been performed up to the present writing. Three patients have been operated upon for non-unions using a massive bone graft and a blade plate with no failures.

Everyone realizes, however, that as the series of cases increases failures are going to occur; but it is believed that if the immobilization and reduction are well done, the number of failures will be few.

TREATMENT

It is an axiomatic principle that the sooner the fracture is reduced and placed in anatomic position the less is the reaction of the tissues to trauma and the quicker the healing process takes place. Therefore, it is ideal when supracondylar fractures can be reduced anatomically as quickly as possible with sufficient internal

fixation so early mobilization of the knee joint can be undertaken. By so doing the period of convalescence will be shortened and the resulting loss of knee motion will be minimized. Under the best of circumstances one has to accept a certain amount of loss of knee motion which frequently amounts to 30 to 60 degrees of knee motion and is never regained.

Postoperatively, whether it be a fresh fracture or non-union of long duration, as soon as there is evidence of callus formation to assure one that the fragments will not become displaced, physical therapy is instituted. First it is done passively by the patient with a Pearson attachment; later it is done passively by the physiotherapist, and finally it is done actively by the patient. This requires a great deal of cooperation between the patient and the physiotherapist and only by the intelligent cooperation and understanding of the problem can one hope to attain the maximum end result.

The operative procedure through the soft tissues is identically the same in new and older cases. It has been our experience that the best method of approaching this area is through an anterolateral incision about 6 to 8 inches in length, depending on the underlying pathologic condition. The lateral margin of the rectus femoris is carefully isolated and it is separated from the vastus lateralis through the line of cleavage. This brings one down upon the vastus medialis which in this area is not very vascular. The fibers are split longitudinally and all the bleeding carefully controlled. The authors prefer to do this type of surgery under an elastic or a pneumatic constrictor so that the field is bloodless. The operation can then go along much more speedily and there is minimal loss of blood to the patient which decreases the possibility of postoperative shock.

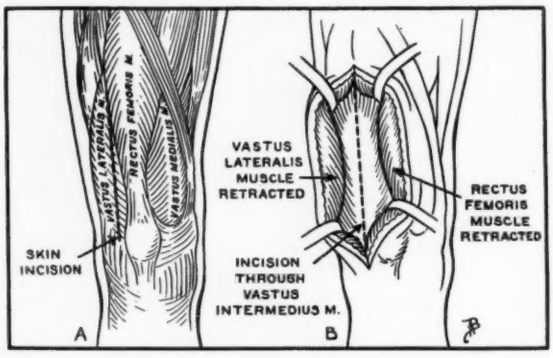
The incision should be extended down to the lateral margin of the patella. One need not fear entering the knee joint. Adequate exposure is imperative in order to do a successful reduction. A subperiosteal dissection brings the femoral fragments into view and by retraction all the important structures in the popliteal area are kept away from the operative field. It is necessary to be able to visualize not only the lateral aspect but also the anterior aspect of the femur in the area of the fracture. This can be successfully done by drawing the patella and rectus femoris muscle medially. Careful reapposition of the bone is attained. We have found it advantageous to use the blade plate of adequate size so that the blade portion can penetrate through the external condyle into the medial condyle of the femur and give good fixation. The right angle portion of the blade plate with the holes for screw insertion is then carefully bent to conform with the femur and then the screws are inserted for firm immobilization of the proximal fragment. In fresh fractures this can be attained without too much difficulty and without too extensive dissection or curettement of the injured bone.

If there are some defects in the area because of comminution, it has been our experience that osteogenesis is helped considerably by taking a mass of osteoperiostea grafts from the shaft of the femur and carefully packing them into the defective area. The closure of the muscle layers and fascia is done with No. 000 chromic catgut and black silk used for skin closure. The wound is covered with sterile dressings and then a moderate compression bandage is applied using fluffed gauze or mechanic's waste with a superimposed Ace or Tensor type of elastic bandage. This minimized the postoperative oozing and prevents postoperative edema which occurs if moderate pressure is not exerted. All cases are placed in Buck's extension with 5 to 10 pounds of weight; or if the skin has been poor in the area of the calf, a Steinman pin is inserted either through the tibial tuberosity or through the os calcis. Postoperative immobilization in traction is necessary until early evidence of callus formation takes place which usually is in from four to six weeks. Physical therapy can be instituted as soon as there is callus formation so that one need not fear loss of position of the fractures and disruption of the early signs of union.

Usually at the end of about ten to twelve weeks the patient has regained a substantial amount of knee motion with the assistance of the physiotherapist and the use of the Pearson attachment by the patient while he is in bed. An ischial weight-bearing caliper is then used for a period of about five to seven months from the date of surgery until there is no question but what the patient has a solid bony union at which time the brace is completely discarded.

Non-unions of supracondylar area present a different problem. The knee joint as a rule is very rigid, the patient is unable to walk because of instability and non-union is visible

on the x-ray and at operative findings. The bone ends are avascular, the bone may be very hard and chalk-like in consistency and all evidence of bone regeneration has completely ceased. In these cases it is believed that the patient not only requires adequate immobilization but also requires a substantial massive bone graft to produce a solid bony union. The operative approach is through the same layers of tissue and through the same type of incision as described previously for fresh fractures. (Fig. 11.) A massive bone graft is removed from the same tibia, usually 6 to 7 inches in length, depending on the area requiring the graft and the extent of the pathologic disorder. The bone graft is inserted on the anterolateral aspect of the femur and condyles. (Fig. 12.) It is necessary that the rounded surface of the femur is flattened so as to take a flat graft and obtain the maximum amount of contact of bone to bone. If one will make a tunnel into the condyles and sharpen the end of the graft, the massive graft can be driven into the femoral condyles and under direct vision can be inserted until it just reaches the articulation of the femur. The farther distally the graft can be inserted the better is the fixation of the graft and the better the chances of a good solid union. By inserting the graft in this slot fixation of the massive graft by screws is only necessary on the proximal fragment. The distal fragment is completely surrounded by cancellous bone which heals rapidly, holds the cortical bone graft from the tibia firmly and requires no further fixation. In order to permit early mobilization of the knee joint and to assure against a fracture of the graft, a blade plate is placed on the lateral aspect of the femur. (Fig.



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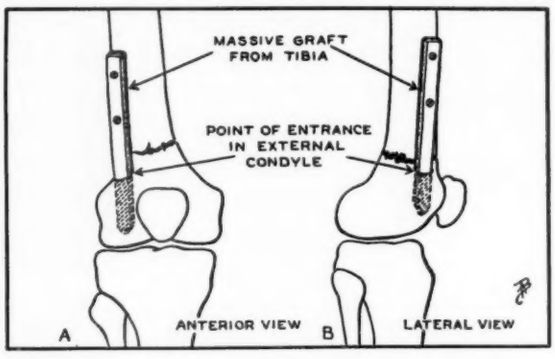

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FIG. 11. Shows the recommended surgical approach to this area, as found best by the authors. A 6 to 8 inch longitudinal incision is made parallel to the lateral border of the rectus femoris, opening the knee joint, and exposing the femoral condyles. The patella and quadriceps muscle are retracted medially exposing the entire supracondylar and dicondylar areas of the femur. All cases are done under a high thigh constrictor so as to prevent loss of blood, and also to permit a more rapid operation because of better visibility.

FIG. 12. A tibial bone graft ½ by ⅝ by 6 to 7 inches in length is taken from the same tibia so as not to have two damaged legs at the same time. A joint is made in one end, and this end is driven into a previously made tunnel into the femoral condyle where it becomes firmly held by the surrounding cancellous bone. Then two screws are used to fix the graft into the proximal fragment. It is recommended that the graft be placed on the anterior lateral aspect of the femur for the insertion of the blade plate.

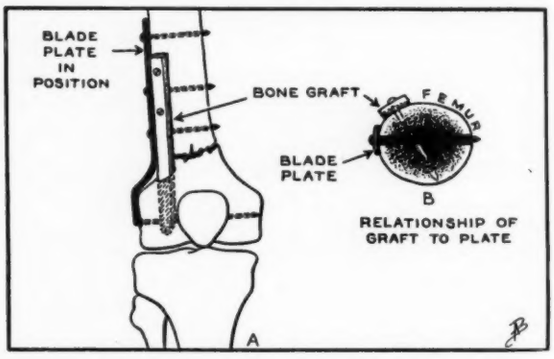

FIG. 13. Shows the relationship of the blade plate to the graft. This relationship lends itself to firm fixation, good visibility at the time of surgery and the least interference to the quadriceps extension mechanism. Postoperatively these cases have been placed in skin or skeletal traction using 5 to 10 pounds of traction. This is kept on for four to six weeks depending upon the case when a Pearson attachment is applied to the Thomas splint and passive motion of the knee is instituted by the patient. Physical therapy is then begun and must be carefully supervised so that rapid restitution of knee motion is attained without endangering the fracture. Fresh fractures in younger people require less immobilization than those patients having required a bone graft, or in individuals of advanced age who usually are somewhat slower in developing callus.

13.) This has to be bent to conform with the contours of the femoral condyle and lateral aspect of the femoral curvature. Fixation is then obtained by the use of two, three or four screws into the handle of the blade plate.

The closure is the same as it is in fresh fractures. The treatment likewise is the same. It is most important, however, in these old non-unions that mobilization be started as early as feasible, because there already exists a considerable amount of periarticular fibrosis and one does not wish to have more accumulate. Beside physical therapy is very important even while the patient is in traction, especially in the form of quadriceps setting exercises.

In our cases the usual period of time from insertion of the bone graft until the patient can walk without the assistance of a brace is six to eight months.

CONCLUSIONS

1. In non-unions of supracondylar fractures of the femur a massive bone graft from the tibia with a blade plate for maintenance of reduction of the fracture has been found to be an excellent form of treatment. Three cases have been successful and the patients followed up for over sixteen months.

2. Fresh supracondylar fractures of the femur with displacement constitute adequate indication for an open reduction and blade plate fixation.

3. Early, accurate reduction of this type of fracture produces more rapid healing, and early mobilization after the soft tissues have healed, minimizes the restriction of knee motion. The help of a cooperative patient and an understanding physical therapist are indispensable.

4. The operative procedure under a constrictor is not technically too difficult; the exposure is anatomic and does not endanger any of the important structures in this area.

5. Three cases of old non-union and seven cases of fresh fractures are being reported in this group with no failures to date.

DISCUSSION OF PAPERS BY DRS. EGGERS, GALLAGHER, SCUDERI AND IPPOLITO

CHARLES S. VENABLE (San Antonio, Tex.): I am not going to discuss how a hip is nailed because there have been new hips and new nails and ways of fixing them ever since I was a boy, and every time we come to a meeting we get some more ways of nailing hips. However, I do not think we are paying enough attention to the postoperative care or the protective care of fractures of the neck of the femur. I will not go into the fractures but I want to comment particularly on care after reduction. I think that is obviously seen today in the frequency of postoperative surgery, following the fracture of the femoral neck, in which we have to remove the femoral heads and replace them with varying prostheses.

There is a principle which we must remember to follow, which is that in standing with our legs straight, the neck of the femur is downward and outward in abduction, obliquely from the body, as we stand, walk or lie in bed in this position, is across the fracture site, which is mid-way across this oblique plane of the femoral neck.

If the leg is abducted, the weight is in line with the neck of the femur and, therefore, as the patients walk in abduction, they are not doing the damage at the fracture site that is done with the limb straight or adducted when the nail is loosened by progressive extraction with all the strain at the fracture site. Remember the end of the nail goes past the fracture site in the neck of the femur only 2 or 3 inches into spongy bone while they are trying to carry all their weight against an oblique plane.

We have all been taught to put sand bags in bed between the legs to maintain abduction of the fractured limb after internal fixation of some sort, and we have been taught to direct the ambulatory patient to sit with the leg in abduction. I know and I think you know also that these directions are of common knowledge but are not very carefully carried out.

In order to overcome this I have developed a very light and easily handled abduction splint, which is nothing in the world but a Thomas Full Ring splint with the bars cut off above the knee and incorporated in a leather sleeve which is to encase the limb and control the desired abducted position of the thigh by means of a band around the waist which is attached to the upper-outer margin of the ring by two straps before and behind the outside bar of the splint, which prevent rotation at the hip. The tighter the waist band is drawn the further the extremity will be forced into and held in abduction. Patients may sit, walk, bear weight and do anything they choose as long as constant controlled abduction is had.

Remember that the neck of the femur is soft bone and that it takes much longer for that to attain a strong union. You do not have callus forming in soft bone so one must have a melding of new soft bone. This is finally sufficient to bear weight.

BARBARA STIMSON (Poughkeepsie, N. Y.): I think Dr. Gallagher is to be complimented upon his very

interesting and remarkably simple apparatus. I have only one suggestion to make. Judging from the films that he has shown, I would suggest that when he operates upon one hip in Madison that, before the patient is off the table, he stick a Smith-Petersen pin in the opposite hip to save trouble later on. Apparently they run to double fractures up there.

It is a very neat gadget and looks rather foolproof.

I would like to ask Dr. Scuderi one question and that is, what does he mean by early mobilization?

G. W. N. Eggers (Galveston, Tex.): I think it is about time for us to think a little bit about the real value of the bone graft. I am not convinced that a bone graft the size that is being used, not only in the papers presented here but also in general, is the answer to the union which is obtained. If you get union in the shaft of the femur, an extensive union like Dr. Scuderi showed, I am not convinced that the graft was the etiologic factor of that union. In fact, I have had some cases of non-unions when I have not used any grafts but simply had good apposition and good lines of compression and continuity of bone and they recover whether a graft is used or not.

The point is that we are probably giving a lot of credit to something that is not due it. I think a lot of the successful results he obtained are due to very, very excellent technics, excellent realignment. The graft is there probably just to sit around until it can be revascularized in a year or two, the same as the tibia graft. It is the shaft of the femur that unites and the graft remains a while and maintains a certain continuity of changing the shearing forces to compression forces. It is not the graft. It is the absolute union of the shaft which has been accomplished. I think very often we are giving credit to a graft where credit is not due.

John T. F. Gallagher (closing): I wish to thank Dr. Stimson for her comments and in closing point out that the pelvic anchor and protractor enables the operator to accomplish with relative ease whatever type of reduction is indicated. Just what effect this will have in reducing the incidence of non-union and aseptic necrosis remains to be seen. For example, it is an easy matter to perform the technic described by McElvenny, i.e., creating what amounts to an osteotomy by shifting the neck fragment inside and under the head. This insures a greater percentage of bony union at the fracture site. But as Kellog Speed has so aptly stated, down through the years, femoral neck fractures remain the "unsolved fracture." We are still groping around in the dark.

Carlo Scuderi (closing): Dr. Stimson has asked a very difficult question. What do we mean by early mobilization? What we mean by early mobilization is that we do not like to start moving these legs until there is good healing of the soft tissues we have operated upon, and we do not start bending these knees usually under three to four weeks. We usually put the patients in a Pearson attachment and let them work it themselves and then have judicious physical therapy in private institutions without the use of too much force. I think that is what I mean by early mobilization. I am not in favor of moving these people until the soft tissue is definitely healed because I think by so doing you increase the amount of fibrosis, especially around the knee if you have opened it up.

As to Dr. Eggers' discussion, it is a very difficult problem also to answer. However, we have all seen cases that have had end-to-end apposition and no union and it has gone on for months and months, sometimes several years. All at once you operated and put a big piece of fresh, living bone in and, within a period of four to five months, it suddenly grows callous and heals.

We have followed the teachings of Dr. Dallas Phemister not to disturb the fibrous material at the end of the bones. If you stimulate this tissue with fresh bone, it will go on and solidify. During my experience in the service, I operated upon a goodly number of cases that had similar types of non-union. We did not disturb the fibrous material unless there was frank interposition of tissue, and most all of the cases went on to a solid bony union.

I believe that a massive bone graft for non-union is much like what a starving man needs when he is picked up on a desert island. He needs fresh food, plenty of it, and the best thing that we have for starving bone that is not growing well is fresh bone. We have not perhaps had accurate enough scientific observations to enable us to say which case would eventually heal if we kept it mobilized long enough, but it has been my experience that if you put in enough bone—fresh bone in the area—it will form bony callus and heal. I think the error we make most frequently is that we are a little economical with the fresh bone. It is our experience that these cases certainly unite a lot faster in our hands if we put fresh bone in.

THE INFERIOR RELATIONS OF THE GLENOHUMERAL JOINT

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Montreal, Canada

OUR knowledge and understanding of many surgical disorders have been advanced by the investigation of the associated problems from all possible angles. Dr. Codman and Mr. Bankart have made valuable contributions to our understanding of shoulder lesions by focusing attention on the essential post-traumatic anatomy. The shoulder has frequently been explored from the anterior, superior, posterior and lateral aspects. The present antibiotic and chemotherapeutic era enables a further study of this joint from the inferior aspect.

Scholars will recognize that this approach is not in any way new, and the author would like to state immediately that the older surgeons sometimes used this route for drainage of suppurative arthritis involving the shoulder joint; that Langenbeck is said to have approached the shoulder through the axilla although I have been unable to trace this reference and that T. T. Thomas routinely plicated the capsule for recurrent dislocation through the axilla.

Some years ago Dr. Bunnell interested me in this study and my early inquiries quickly revealed that surgery through the armpit was regarded with considerable scepticism because of the danger of infection. The following is an excerpt from personal communication with Dr. Bunnell:

"I have just completed a second edition and in this have told a little more about the axillary incision that I have been advocating as an excellent approach to the shoulder joint in the scapulohumeral angle. There is, as far as I know, no picture showing the anatomy with the arm raised above the head. One must reconstruct it in the mind from the conception of anatomy with the arm down, or what is better, inspect the anatomy on the fresh cadaver. The following pictures may help. Page 298, Spalteholtz, shows the view in a cross axillary incision which allows one to approach the plexus from the posterior aspect. The incision I am advocating is not this, but enters behind the latissimus and teres major. The illustrations on pages 305 and 306 of Spalteholtz show the cleavage between the teres major and long head of the triceps. In Cunningham, pages 377 and 378, the entrance is shown in the triangle between teres major and minor and by the long head of the triceps. On page 24 or 23 in Grant's, the entrance is in the triangular space.

"My incision is exactly paralleling the wrinkles across the rear part of the axilla. It will be seen as one deepens the dissection that anteriorly spanning the shoulder joint are the latissimus dorsi and a little further down on the humerus the teres major muscles. These are right side up, according to our usual conception. Posteriorly spanning the joint is the long head of the triceps upside down, according to our usual conception. The head of the humerus presents between these two and traversing around its neck in full view is the axillary nerve which branches near the triceps muscle to the teres minor. The insertion of the subscapularis is clearly visible in the angle between the nerve and the teres major. The quadrilateral space has been opened up by lifting the triceps from across the two teres muscles and the axillary nerve has moved up with the arm. The head of the humerus as usual separates the two teres muscles. The patient lies on his back rolled one-third over to the opposite side with the arm completely raised. One first uncovers the anterior surface of the latissimus dorsi and teres major and from there traverses backward. This gives the most direct approach for the Bankart operation, and, also, for adhesions in the scapulohumeral angle."

In our own hospital a generation ago a fracture-dislocation was explored through the axilla with subsequent infection and death of the patient. This experience discouraged the use of this approach until the present study. It is certain, however, that with proper selection of cases and careful preoperative preparation surgical procedures can be safely performed with the protection afforded by antibiotics.

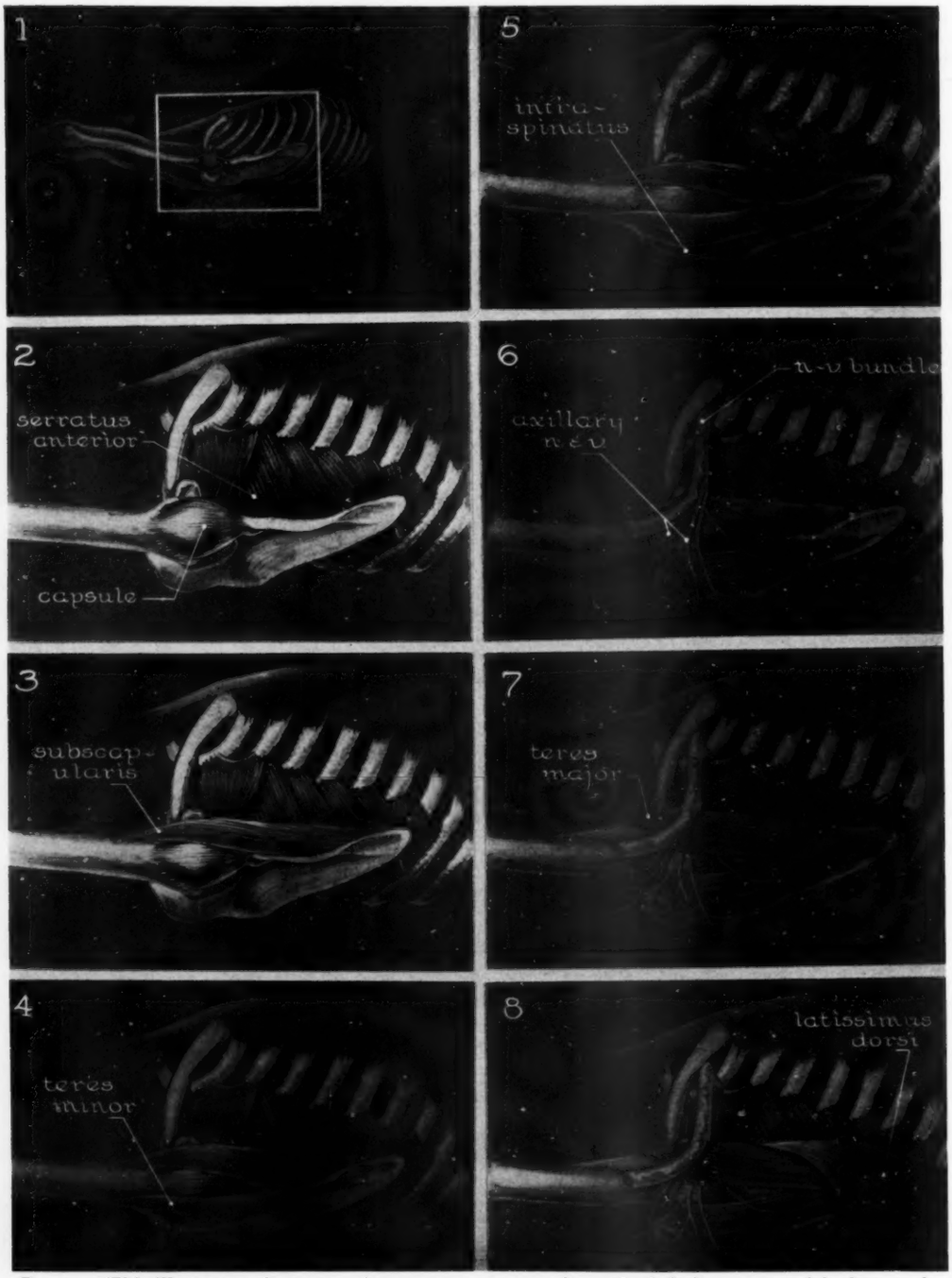

PLATE 1. This illustrates the anatomic structures as seen from the inferior aspect with the arm in complete elevation. The structures are superimposed layer by layer starting with the skeleton. Figure 1 gives the orientation for subsequent views. Figure 2 shows the inferior aspect of the glenohumeral capsule with the addition of the serratus anterior. Figures 3 to 5 add the components of the cuff, subscapularis, teres minor and infraspinatus. In Figure 6 the neurovascular bundle is superimposed and the relations of the axillary nerve and vessels to the capsule and adjacent structures are detailed. In Figures 7 and 8 the posterior boundary of the axilla formed by the teres major and latissimus dorsi is depicted.

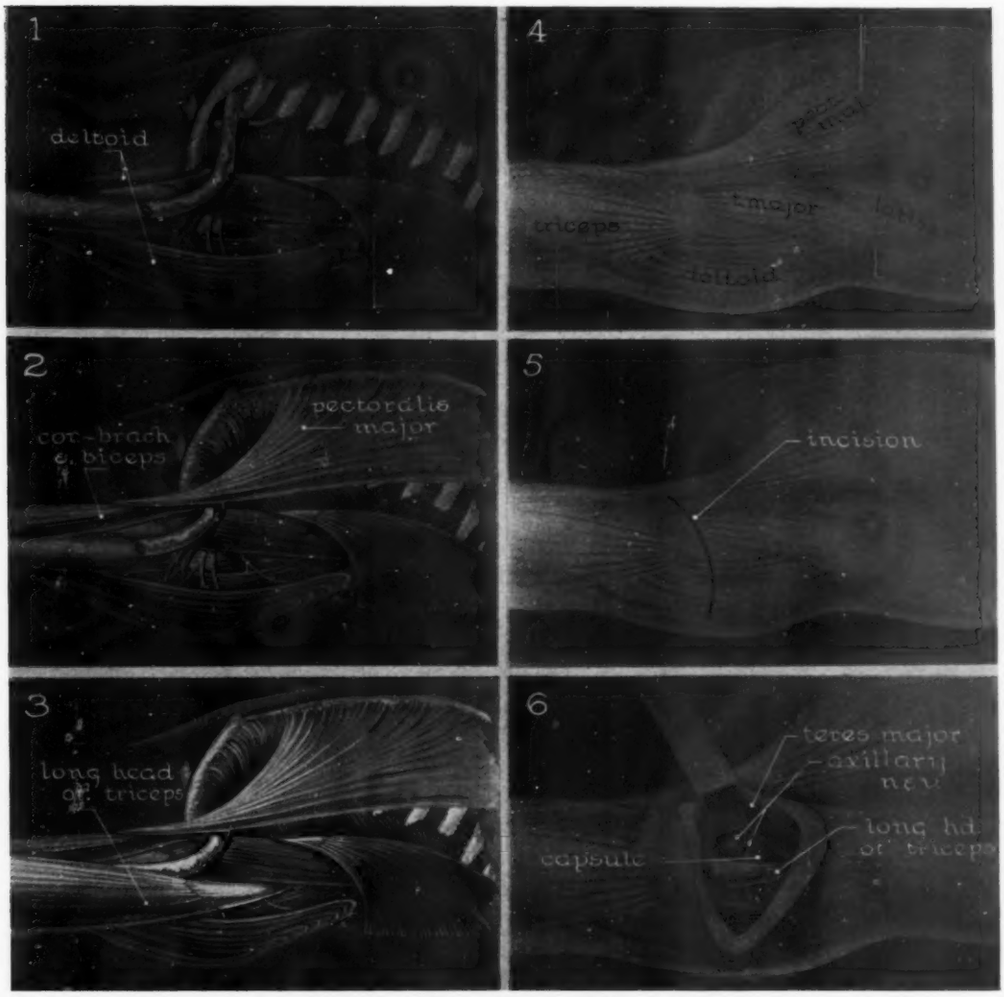

PLATE 11. Figures 1 to 3 continue the build-up begun in Plate 1. The pectoralis major is seen to constitute the anterior boundary of the axilla. The important landmark, the long head of triceps forms a strong support to the inferior capsule in the position for dislocation. Figures 4 to 6 indicate how the knowledge gained from the preceding drawings assists in understanding the posteroinferior approach.

For this reason it was believed practical to study in detail and present for your consideration the anatomic relations of this region. This paper should be correlated with the film made during this investigation.*

ANATOMIC CONSIDERATIONS

Traumatic and orthopedic surgeons must rewrite and illustrate anew the classic anatomy which is executed in the anatomic position. They must describe and depict the changing relations in the varied positions of function and for operation. This is especially true for the study under consideration. When I first began this work, friends quickly said it should be titled "The Axillary Relations of the Shoulder Joint." I asked them what they meant by the axilla and they naturally replied, "the armpit." When asked where the armpit was actually situated they simply replied, "under the arm." When asked to indicate with their hand they applied the examining hand beneath the pectoral muscle and indicated the hollow which existed. However, once the limb was placed in the completely elevated position, they noted that the armpit as such was usually obliterated as a hollow by the descent of the humeral head and the tension of the climbing muscles. As

* D and G Surgical Film Library. Inferior Relations of the Shoulder Joint (Surgical Anatomy). Dr. H. F. Moseley, 1950. Two reels, silent, color, twenty-one minutes, No. 494.

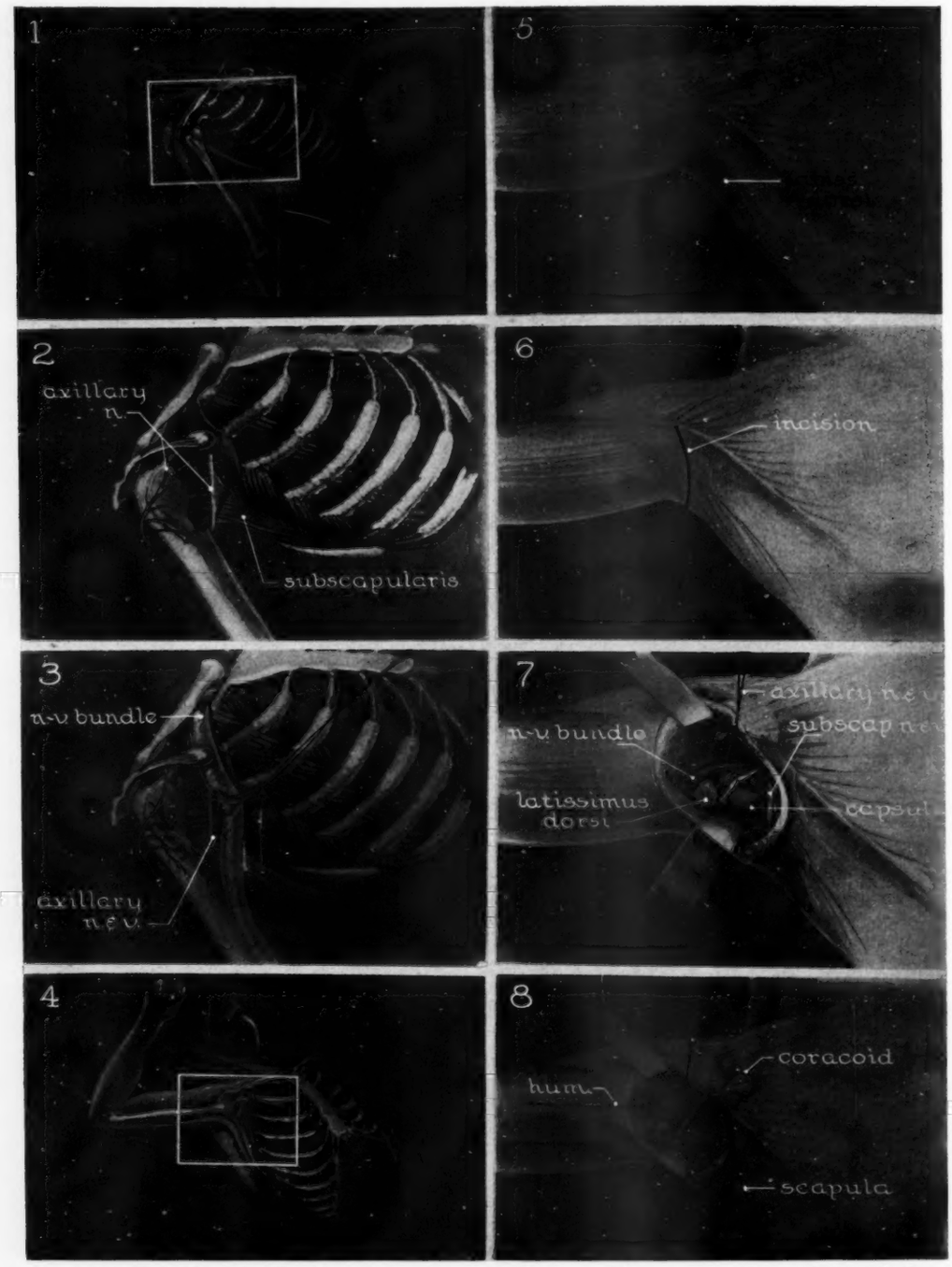

PLATE III. This plate details the structures, especially the axillary nerve and vessels, required to visualize the anteroinferior approach. Figures 1 to 3 show the axillary nerve and vessels lying just medial to the musculotendinous junction of the subscapularis and covered by the neurovascular bundle. The course of the nerve and vessels is over the muscular lower border of the subscapularis and through the quadrilateral space. Figures 4 to 8 demonstrate how the preceding drawings assist us in understanding the anteroinferior approach.

the axilla or armpit by exact definition lies in front of the teres major and latissimus dorsi and as Dr. Bunnell's exposure lies behind these structures, it is best described as the *posteroinferior approach* and the approach used by T. T. Thomas as the *anteroinferior approach*.

The surgical relations determining these exposures will be best understood from Plates I to III.

SUMMARY AND CONCLUSIONS

The inferior exposures have been detailed. These have been used on four cases of recurrent dislocation. The knowledge gained indicates that the inferior aspect of the shoulder joint is not a weak area as usually described and is strongly supported in the position of dislocation, i. e., abduction, by the tendon of the long head of the triceps.

The inferior approaches give an excellent exposure of the axillary nerve and vessels. This study indicates that Nature protects the nerve from injury by arranging muscular lower portions of the subscapularis and teres minor muscles which act as a buffer, whereas if the inferior borders of these anterior and posterior cuff muscles were tendinous, there would be greater tendency to injury. It is also noted that the nerve follows the neck of the humerus and is away from the glenoid rim where most avulsions occur and the possibility of injury is thereby diminished.

The anteroinferior approach gives the better exposure of the anteroinferior glenoid rim for study of recurrent dislocations, although when the inferior approach is used, the post-traumatic anatomy will be studied both anterior and posterior to the latissimus dorsi and teres major muscles. Experience does not permit the relative evaluation of these exposures and the anterior approach in the deltopectoral interval with section of the pectoralis major published by Dr. Speed. Both give excellent visualization and that of Dr. Speed is the less difficult to perform.

The inferior approaches are chiefly indicated in cases of axillary nerve paralysis. Operative studies should add to our detailed knowledge of such cases.

One complication is recorded, namely, traction injury to the C_{5-6} nerves from forced positioning of the head and shoulder. Complete recovery ensued but this complication should be remembered when the arm is hyperabducted and the head forcibly turned to the opposite side for anesthetic purposes.

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THE STRENGTH OF HUMAN COMPACT BONE AS REVEALED BY ENGINEERING TECHNICS*

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ALTHOUGH the treatment of fractures has interested surgeons for many years, little attention has been given to a study of the physical properties of bone, the material with which they are dealing. Most of the research on this fundamental problem has been done by Europeans and the classic papers of Rauber,[1] Messerer[2] and Hulsen[3] were all published before 1900. These early studies were primarily concerned with the strength, modulus of elasticity and specific gravity of bone, the results obtained by Rauber and Messerer being the most frequently quoted in English language textbooks. Rauber investigated the physical properties of tiny cubes of compact bone while Messerer studied them in intact bones. However, neither author gave much data on the individuals whose bones were studied or stated the accuracy of their testing technics.

Interest in the physical properties of bone has been revived by the work of Maj,[4-6] Toajari,[7] and Evans and Lebow.[8] In contrast to the earlier investigators these later workers have also studied differences in the strength and other physical properties within a single bone. The stresses and strains occurring in bones have also been reinvestigated and of special interest is the recent demonstration that linear fractures of the skull[9] and the femur[10] arise from failure as the result of the tensile stresses in the bone.

In view of the importance of tension forces in the fracture mechanism the present study was undertaken to determine the actual tensile strength per unit area of compact bone. For this purpose the bone specimens were tested under direct tension forces instead of by cross-bending as most of the previous investigators had done. Thus the compressive forces involved in cross-bending tests were eliminated. Hulsen[3] also tested his specimens under direct tension but the type of testing machine used was not as accurate as the one employed in the present study. In addition, he did not investigate regional differences within a single bone.

The percentage elongation occurring in a specimen during a test was measured as indicative of the amount of energy (in. lb./in.^{3}) the specimen absorbed up to the time of fracture. Neither of these properties of bone had been studied by the previously mentioned investigators.

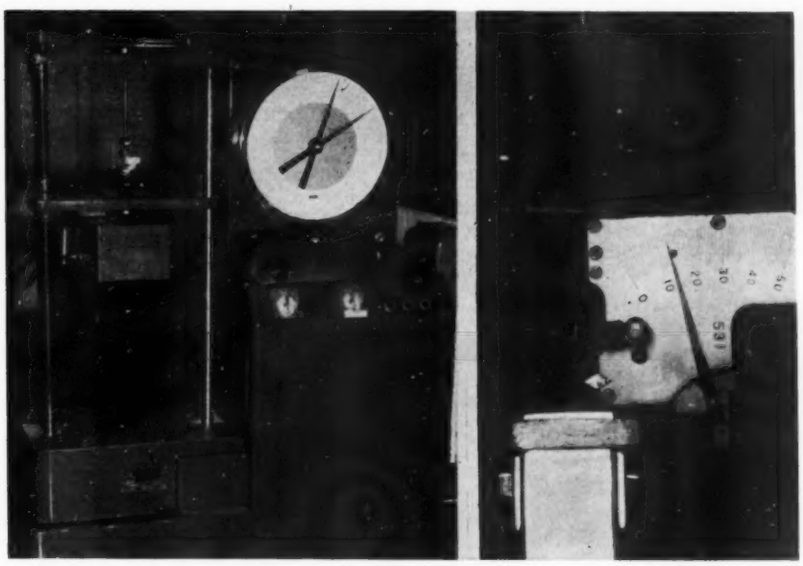
The influence of drying upon the physical properties of bone was included in the study because the results reported by some of the earlier students of the subject had been obtained from dry specimens while others used fresh material. In order to determine the effect of drying, half of the specimens from several femurs were air dried at room temperature and tested dry. The other half of the specimens were placed in a physiologic salt solution and tested while wet.

METHODS

The specimens to be tested were cut longitudinally from the proximal, middle and distal thirds of the long bones of the inferior extremity and then shaped to a standardized size in a milling machine. Each specimen had an over-all length of 3 inches with a reduced area 1½ inches long in the middle of the specimen. The dimensions of the reduced area, the region in which the strength of the specimen was actually determined, were 0.150 by 0.090 inches. The specimens were held in jaws especially designed for tension testing so that the greater the tension, the tighter the grip.

The specimens were then subjected to a direct tensile force in a 5,000 pound capacity materials-testing machine (Fig. 1A) and their tensile strength at the time of fracture determined in lb./in.^{2} The low range scale of the

* From the Departments of Anatomy and Engineering Mechanics, Wayne University, Detroit, Mich. This investigation was supported in part by a research grant from the National Institutes of Health, United States Public Health Service.



1A 1B

FIG. 1. A, The testing machine with the specimen in place; the specimen was tested under direct tension and the load applied was recorded, in units of 0.5 pound, on the large dial of the machine. B, close-up view of the specimen in the jaws and with the Porter-Lipp extensometer attached. The extensometer measured the strain or deformation, in units of 0.0001 inch, occurring in the specimen during a test. The gage length is 1 inch.

machine (0 to 250 lb.) was used so that the load applied to the specimen was recorded on the dial of the machine in units of 0.5 lb. The strain or deformation occurring in the specimen during a test was measured, in units of 0.0001 of an inch, by a Porter–Lipp extensometer attached to the reduced area of the specimen. (Fig. 1B.) The accuracy of the method was approximately ± .5 per cent. From the data obtained a stress-strain curve to fracture was plotted for each specimen.

The bones tested were obtained from cadavers used in the anatomy laboratory at Wayne University College of Medicine. Cadaver material was used because intact fresh femurs, tibias and fibulas, especially from a single individual, were not obtainable. The age, sex, race and cause of death were known for each individual whose bones were tested. Both femurs from seven individuals were studied first, 242 specimens being tested. All the femurs were from white males varying from forty-seven to eighty-one years of age. Later a similar series of tests were made on specimens from all the long bones of the inferior extremity of a white male thirty-six years of age, another forty-seven years of age and a Negro seventy-two years of age. These individuals were selected as representative of a young, middle-aged and elderly male. In this series 115 specimens from six femurs, 109 specimens from six tibias and twenty-five specimens from six fibulas were tested. This part of the study is still in progress so the results found are only indicative of trends based entirely on the material thus far tested.

RESULTS

The results obtained from the series of tests on the femurs alone will be reported first as they are the more extensive. Drying the specimens considerably increased their average tensile strength (lb./in.^{2}) regardless of the region of the shaft from which they were obtained. (Fig. 2.) The specimens from the middle third of the shaft, whether tested wet or dry, had the greatest average tensile strength.

The influence of drying upon the percentage elongation of bone under tension (Fig. 3) is the reverse of that for tensile strength, the wet specimens exhibiting considerably greater elongation than did the dry ones. Considerable regional differentiation was also evident among the wet specimens, those from the middle third of the shaft having the greatest average elonga-

tion. Little regional variation was found among the specimens tested in the dry condition.

The wet samples could also absorb more energy before fracturing than could the dry ones as was evident from their greater percentage elongation. The latter factor is a good indication of the energy-absorbing capacity of bone because the two properties, percentage elongation and energy absorbed to failure, are directly related. Thus when these two physical properties for all the samples from the left femur of a seventy-eight year old white male were plotted against each other, a straight line was obtained. (Fig. 4.) The total amount of energy absorbed was 83.6 in. lb./in.^{3} for the wet specimens and 69.0 in. lb./in.^{3} for the dry specimens. These values were obtained by measuring with a planimeter the area under the stress-strain curve for each sample.

A comparison of the stress-strain for a dry and wet specimen (Fig. 5) also shows the greater energy-absorbing capacity of the wet specimen. The curve for the dry specimen is a straight line to fracture while the curve for the wet specimen deviates from a straight line as the fracture point is approached. In each case the area beneath the curve represents the energy absorbed by the specimen up to the time it fractures. Thus the tests showed that the middle third of the femoral shaft had the highest average tensile strength (lb./in.^{2}) and the greatest energy-absorbing capacity. The age of the individual whose femurs were studied (Fig. 6) seemed to have little influence on the aforementioned physical properties.

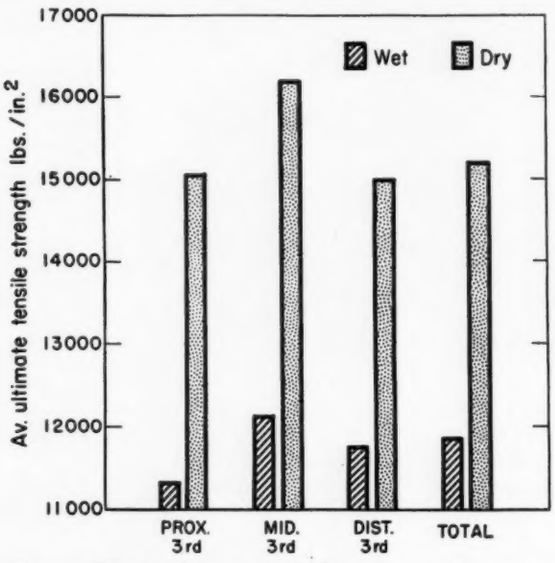


FIG. 2. The influence of drying upon the average tensile strength (lb./in.^{2}) of 242 specimens of compact bone from various regions of the human femur. In this and the following figures "wet" and "dry" refer to the condition of the specimens when tested.

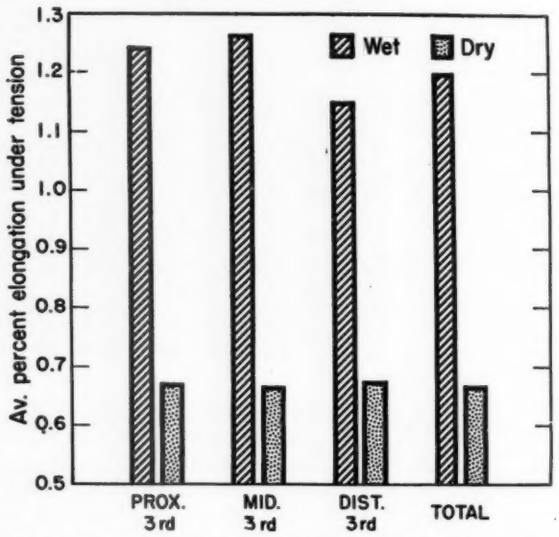


FIG. 3. The influence of drying upon the average percentage elongation under tension in 242 specimens of compact bone from various regions of the human femur.

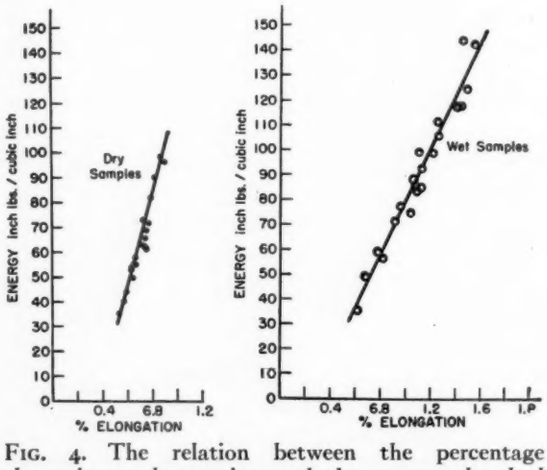


FIG. 4. The relation between the percentage elongation under tension and the energy absorbed (in. lb./in.^{3}) to fracture in specimens of compact bone from the femur of a white male individual seventy-eight years of age. The greater energy-absorbing capacity of the "wet" specimen is indicated by the slope of the curve.

A comparison of the tensile strength and energy-absorbing capacity in all the long bones of the inferior extremity was also undertaken. For this purpose test specimens similar to those employed in the femur study were

prepared from all the long bones of three individuals.

Analysis of the results showed that the specimens from the middle third of the shaft of each bone had the highest average tensile strength. (Fig. 7.) The same was also true for the percentage elongation in the tibial samples. (Fig. 8.) However, in the femurs and fibulas of these individuals the specimens from the proximal third of the shaft had the greatest elongation. With respect to the average tensile strength of the entire bone the tibia was the strongest but the fibula showed the greatest energy-absorbing capacity as indicated by its percentage elongation. In both of these physical properties the femur was the weakest of the long bones of the inferior extremity.

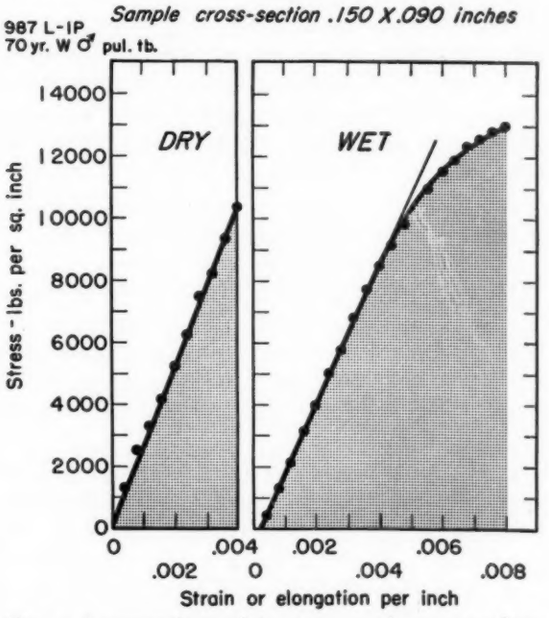


FIG. 5. A comparison of the stress-strain curve to fracture for two specimens of compact bone from the posterior quadrant of the proximal third of the femur of a white male seventy years of age. The stippled area beneath each curve represents the energy absorbed to fracture.

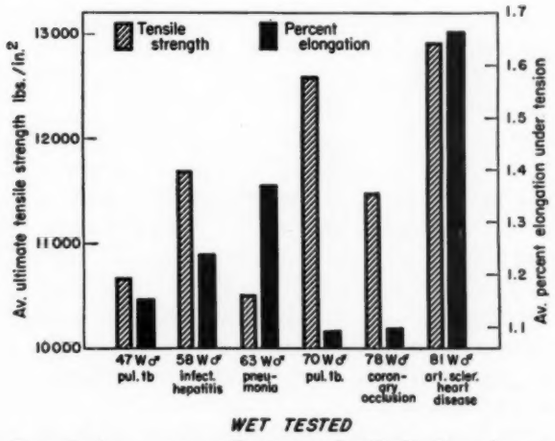


FIG. 6. Average tensile strength (lb./in.²) and percentage elongation according to the age of the individuals whose femurs were tested.

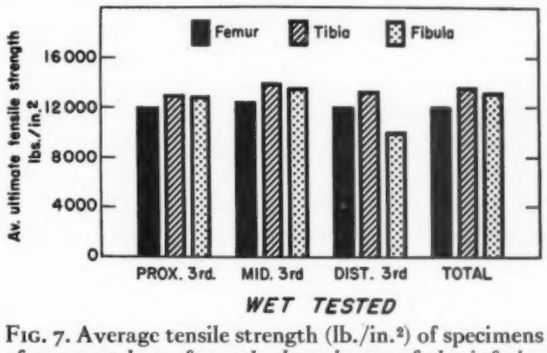


FIG. 7. Average tensile strength (lb./in.²) of specimens of compact bone from the long bones of the inferior extremity of three individuals. The number of specimens tested according to the bone involved was 115 from the femurs, 109 from the tibias and 25 from the fibulas.

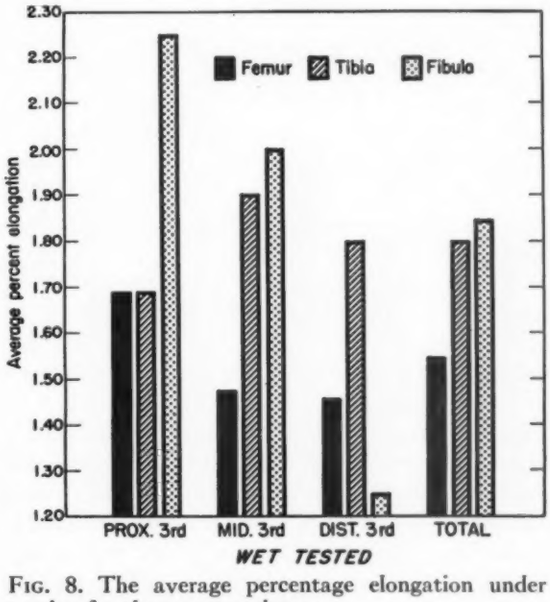


FIG. 8. The average percentage elongation under tension for the same specimens.

COMMENTS

The results of these tests clearly show that bone is not a homogenous material but exhibits considerable region variation in the physical properties of a single bone. Consequently, analyses of the mechanical behavior of bone

based on studies of models of bones should be accepted with reservations for the following reasons: (1) the material from which the model is made, usually some type of plastic, is far more homogeneous than bone; (2) the physical properties of this material are generally quite different from those of bone and (3) the model is a solid structure while a bone, especially a long one, is not. Somewhat similar criticisms apply to mathematical analyses of the mechanical behavior of bones because in such studies it is generally assumed that bone is homogenous throughout and the analysis of the force is based on two-dimensional figures. A bone, however, is a three-dimensional object that is not homogeneous throughout.

The influence of moisture on the tensile strength and energy-absorbing capacity of bone is especially significant as, according to Best and Taylor,[11] marrow-free bone has a water content of 25 to 30 per cent. The change in moisture content from air dried specimens to those oven dried to a constant weight was 12 per cent so that living bone would probably have considerably greater energy-absorbing capacity than we found in our tests. The importance of this from the fracture standpoint is obvious. It also helps to explain some of the variation in values for the tensile strength of bone found by different investigators, some of whom tested fresh specimens while others used dry ones.

The tensile strength and energy-absorbing capacity of bone may also be modified by embalming as Calabrisi and Smith[12] found that embalming reduced the compressive strength of fresh bone by 13 per cent. The effect of embalming upon the physical properties of bone discussed herein is now being investigated by the authors. Since all the material used in the present study was obtained from embalmed cadavers, the values obtained for the tensile strength of bone are probably less than that for living bone.

One of the most interesting results of the comparative study of the long bones of the inferior extremity was the revelation of the high tensile strength (lb./in.^{2}) and great energy-absorbing capacity of the fibula. Although only six fibulas from three individuals have been tested thus far, each of them exceeded the femurs in tensile strength and energy-absorbing capacity. In all individuals the tibia was the dominant bone in these physical properties. Because of the small number of fibular samples tested the results are tentative although a trend is indicated.

The femurs of these three individuals differed from those of our more extensive femoral study with respect to the percentage elongation which was greatest in the samples from the proximal third of the shaft. This was largely because six specimens from the proximal third of the left femur of the white male forty-seven years of age showed a much greater percentage elongation than was usual for our femoral specimens.

SUMMARY

1. The average ultimate tensile strength (lb./in.^{2}) and percentage elongation under tension were determined for 242 specimens of compact bone from the femurs of seven white, adult male cadavers whose age and cause of death were known.

2. All specimens were of a standardized size and were tested by approved engineering technics which are described. Half of the specimens were air dried at room temperature and tested dry while the other half were placed in a physiologic saline solution and tested wet.

3. Drying the specimens increased their average tensile strength (lb./in.^{2}) but reduced their percentage elongation under tension. The percentage elongation under tension is a good index of the energy (in. lb./in.^{3}) absorbed by the specimen up to the time of fracture.

4. The samples tested wet had a greater percentage elongation under tension, and hence greater energy-absorbing capacity, than did the dry samples. This is also evident from the shape of the stress-strain curve which is a straight line to fracture for the dry samples but a curve for the wet specimens.

5. The specimens from the middle third of the femoral shaft had the greatest average tensile strength and energy-absorbing capacity, as indicated by their percentage elongation under tension.

6. The age of the individual seemed to have little influence on the tensile strength and energy-absorbing capacity of the femur.

7. Similar comparative studies on all the long bones of the inferior extremity of three adult male cadavers revealed that the tibia had the greatest average tensile strength

(lb./in.^{2}) and the fibula the greatest percentage elongation under tension. The femur was the weakest in these respects.

8. As in the femur the middle third of the tibia and fibula had the greatest average tensile strength (lb./in.^{2}). The middle third of the tibia also had the greatest percentage elongation but in the fibula, and also the femurs of these individuals, the proximal third of the bone had the greatest elongation. These comparative results should be considered as tentative but also indicative of a trend.

9. The values for the physical properties of the wet-tested specimens probably more nearly approximate similar properties in living bone than do those of dry-tested specimens.

10. The significance and implications of the tests are discussed.

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USE OF GELATINIZED BONE IN SKELETAL TRAUMA*

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THE vast number of different substances that have been employed in the correction of skeletal defects illustrates their inadequacies and poses a challenge to the reconstructive surgeon. Injections of paraffin have resulted in catastrophe. Hard substances such as beef bone, ivory, metals (vitallium, tantalum) and acrylic resins are far from ideal due to their hardness and rigidity, and they must be firmly fixed to the underlying bone if a satisfactory result is to be expected.[1] Slight trauma may dislodge them causing a deformity or encystment which will make their position untenable.[2] Use of the soft or elastic plastics (polyisobutelene[1] or polyethylene)[3] also has many limitations.

One of the axioms of surgical technic is that foreign material should be used only where acceptable living tissue cannot be adapted. The tissues used for the correction of skeletal defects are dermis, fat, fascia, cartilage and bone. The soft tissues (usually autogenous) have limited value because of certain individual peculiarities. Dermis has the advantage of accessibility in large quantities[4,5] but inclusion cysts from the presence of such epithelial elements as hair follicles, sweat glands and sebaceous glands are said to result. If such cysts occur, however, they are usually of microscopic size.[6] There is some fear of infection from the glandular elements of the skin but it never poses a major problem.[7] The fat grafts offer tissue quantity but the absorption is very great. The inclusion of a layer of fascia seems to limit the absorption slightly and a combination of dermis, fat and fascia is the best.[8] Fascia is available from the fascia lata mainly in strips which are utilized only in the repair of small defects. All of these tissues may be used as free or pedunculated grafts with viability more assured if the whole blood supply is not lost.

The supportive tissues themselves offer the best source of graft material. They may be fresh autogenous, preserved autogenous, fresh homogenous or preserved homogenous. Autogenous tissues are usually used fresh while the homogenous tissues are usually preserved (cartilage, chemically preserved; bone, refrigerated). Cartilage had been used most commonly until recently when bone began to surplant it. Although cartilage is advantageous in that it is lymph nourished, that it does not need to be in contact with cartilage and that it is well tolerated by tissues, it is not wholly satisfactory as it tends to twist and curl after transplantation.[9] In the preserved state it does not twist as much as fresh cartilage. In small quantities it may be obtained from the nose (septum) and the ear (auricle) with the largest single piece available from the costal bar. As cartilage will stand only a limited strain, it cannot be used for grafting large areas.

The increased popularity of bone as a graft material is due to its accessibility in quantity and to its ability to withstand strain. When stress and strain are great, compact bone is used while cancellous bone is employed for its healing advantages. A controversial atmosphere surrounds the whole subject of bone grafting. Compact bone grafts are usually obtained from the crest of the tibia while those of cancellous bone usually come from the crest of the ilium. Whether the bone graft is accompanied or not by periosteum is not relevant to the discussion at this time. One type of bone chip graft attached to strips of periosteum may be raised from the tibia or the skull. Massive bone grafts, particularly compact bone, usually die and serve only as a trellis for new bone formation[12,13] while fragmented cancellous bone maintains its viability through rapid revascularization due to the extensive surface area.[10,11] This is particularly true if carried to a minute degree. Satisfactory fragmentation of the cancellous bone may be accomplished by grinding it in a

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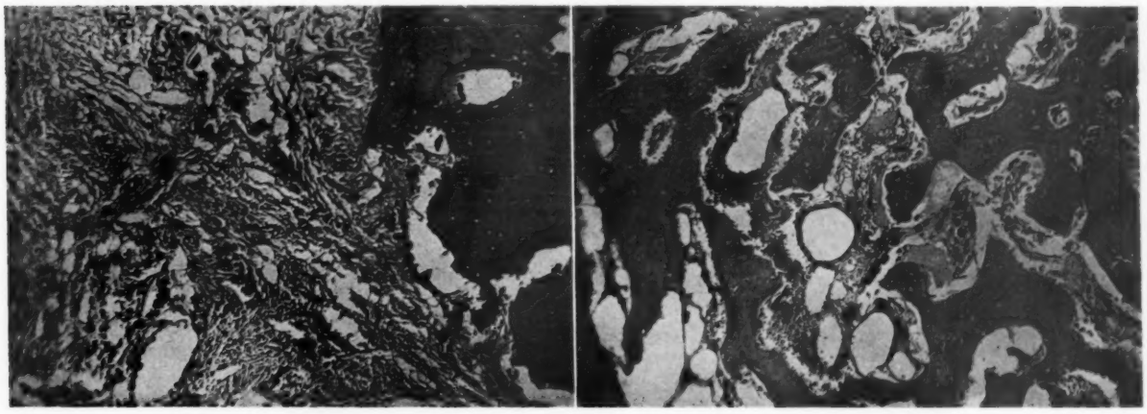


1A 1B

FIG. 1. A, Photomicrograph of healing ground bone twenty-one days postoperatively; B, photomicrograph of healing gelatinized bone twenty-one days postoperatively.

conventional meat grinder. A problem presented itself, namely, the increased difficulty of introducing and maintaining the consistence of the ground material. Cohesion was given by the introduction of fibrin foam and plasma. Considerable fibrin foam was needed and this was probably the reason for the resultant 20 per cent of absorption factor. A more thoroughly satisfactory preparation was made with ground bone, whole blood and powdered gelfoam (bone 2: blood 1, by vol.—8:1 powdered gelfoam).[15,16]

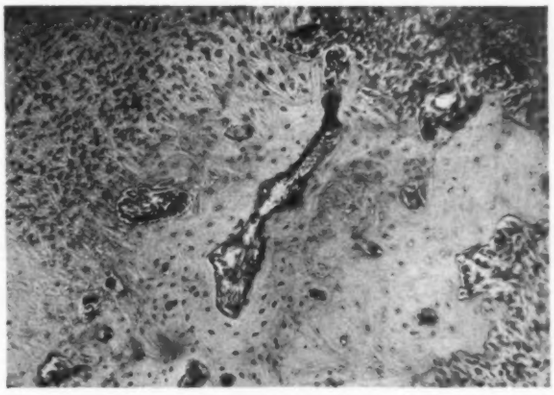


FIG. 1. C, Photomicrograph of healed gelatinized bone six months postoperatively.

EXPERIMENTAL STUDIES

The aforementioned formula was determined by studies of the rate of revascularization occurring on the chorioallantoic membrane of fertilized hen's eggs after the technic described by Murphy.[17] Various preparations of ground bone, both compact and cancellous, were implanted on the chorioallantoic membrane with sterile technic through a small aperture in the shell.[15] The criterion for the discernment of revascularization was the presence of nucleated red blood cells (chick blood) within the implanted mass. These cells were noted in implants of cancellous bone in sixty hours following implantation.[15,16] It is reasonable to believe that there is a nutritional interchange before this time. The findings of Abbott and others[13] were confirmed in that no revascularization of compact bone fragments was noted during the course of these experiments while progressive ingrowths of capillaries were seen in the cancellous fragments. (Fig. 1A, B and C.)

A series of fibular bone defects was made in rabbits by removing an entire section of the bone with a rongeur. In the control leg the fragment was replaced while in the other leg the fragment, embedded in autogenous gelatinized bone, was inserted into the defect. In all instances healing progressed more rapidly when bone embedded in the gelatinized bone mass was utilized. A 60 per cent reduction in healing time was obtained. (Fig. 2A, B, C and D.)

As the healing time of a long bone fracture in a rabbit is approximately fourteen days and in man five to six weeks (ratio 1:2½–3), it is conceivable that a fracture in man could be fixed in firm union in approximately ten days to two weeks. Firm union was noted clinically in the rabbit in four days. (Fig. 3.)

An attempt to discover why the healing was enhanced to this degree raised many complex problems. Some of the factors that might influence this acceleration are: (1) regulation of the pH during the healing period;

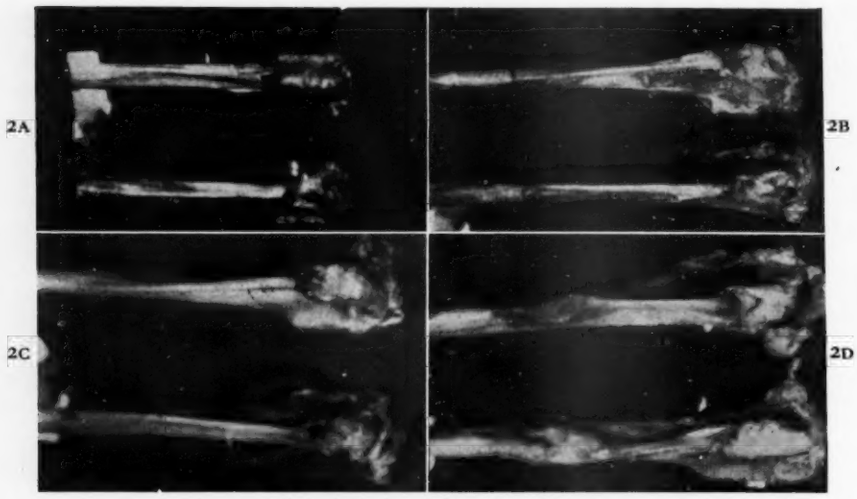


FIG. 2. Comparison studies of fibular defects in rabbits. A, B and C, four, eight and twelve days postoperatively. Top: defect treated without gelatinized bone. Bottom: treated with gelatinized bone. D, Top: defect treated with gelatinized bone. Bottom: treated without gelatinized bone.

(2) introduction of an available quantity of calcium salts; (3) introduction of a large number of active osteoblasts; (4) increase in alkaline phosphatase due to the phosphatase present in the ground bone; (5) introduction of an organizer substance.

It has been shown by many workers[18–21] that in normal growing bone the pH is 7.2 to 7.3. The tissue fluids at a fracture site may drop as low as pH 4.2 within a few hours but in twelve days the pH returns to normal often attaining a peak of pH 8.2 in three weeks.[19] Studies of the pH by the litmus method *in vivo* of Raus[18,22] and the microglass electrode technic[23] were made on healing gelatinized bone transplants. The lowest early reading in any of the cases was pH 6.8 but rarely did the pH descend below pH 7. Elevations in pH were more rapid but they were of less magnitude, usually only to pH 8.

The hydrogen ion concentration is thought to be of importance as activity of alkaline phosphatase is greater in the alkaline pH range. The diffusibility of normal serum calcium is also regulated by pH.[24,26] The lack of the acid shift is beneficial because a low pH is detrimental to calcium deposition.

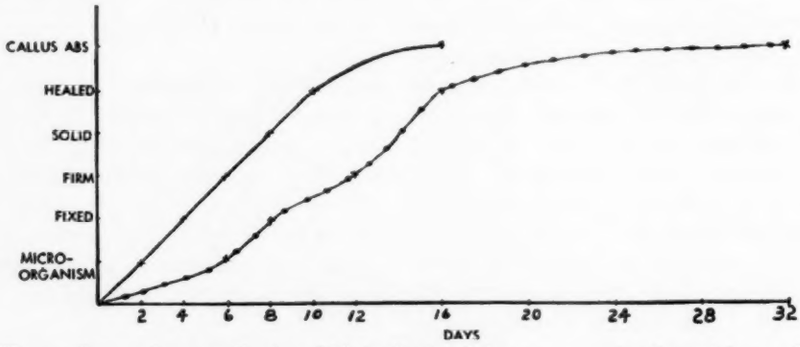


FIG. 3. Comparison studies in rabbit in fibular defects. *——* healing with use of gelatinized bone; •—•—• healing in usual method (natural healing).

There is reason to believe the early drop in pH is essential for calcium transfer from bone ends to the blood clot.[27,29] The pH elevation also aids calcium assimilation as it stimulates the phosphatase activity.[29,38] The subject of bone chemistry is controversial and the role played by alkaline phosphatase in healing uncertain.

The importance of the osteoblasts in the

formation of bone is not questioned. By the same token, the increase in osteoblasts in the gelatinized bone mass should be an acceptable reason for acceleration of bone formation but probably is not the sole reason. The same is true of the added calcium salts to those normally present in bone.

Phosphatase is also synthesized by the osteoblasts.[31] Phosphatase can be extracted from the ground bone mass by ethyl acetate.[32] This preparation of phosphatase shows a definite phosphatase activity when tested by the histochemical method of Gomeri.[33]

The presence of an organizer substance is discussed by Lacroix,[34] Bertelsen[35] and Levander.[36] Alcoholic extracts of bone were shown to stimulate osteogenesis. This substance, never isolated, may explain the acceleration of healing.

It has not been determined which of the five possibilities is the predominant factor. Our experiments have shown that such an acceleration factor, or factors, does exist and is present in the gelatinized bone mass. Confirming our studies, another investigator notes that the regrowth rate of ground bone mass was twice that of periosteum alone, and a third greater than from bone chips.[37]

Both autogenous and homogenous bone have been used with satisfactory but not equivalent results. In at least one of the experimental animals live osteoblasts have been seen in refrigerated homogenous bone fragments. The use of bank bone has advantages in that it is available in quantity and eliminates two operative procedures.

TECHNICS

To prepare gelatinized bone a portion of the iliac bone is cut into small pieces with cutting forceps or a chisel. The bone fragments are put through a meat grinder with a fine perforated outlet in order to produce particles less than 1 mm in size. The resultant material is mixed with fresh whole blood in the ratio 2:1 volume. An eighth part powdered gelfoam is added and the preparation mixed thoroughly. In a short time it attains a gelatinous consistence and is ready for immediate use.

Two methods have been utilized to introduce this substance. If the defect has little scar tissue present, as in malar depressions and some types of saddle nose deformities, the bone mass may be injected beneath the periosteum with a large gauge hollow needle (No. 10 or 12). A small size glass syringe is not satisfactory as the bore of the nipple is too small. Therefore, a 50 cc. syringe with a metal adapter or a metal syringe of comparable size with ring type thumb and finger grips is preferable. If the needle is inserted under the periosteum, the pressure of the injection will elevate the periosteum. When extensive scarring is present or the area has been covered by a thin skin graft, the open method of introduction must be used. The scar tissue is excised or elevated and an incision made along the side of the defect with a tunnel created to the desired site. The soft tissue is elevated from the defect and the bone freshened with a curet. Thorough hemostasis must be effected. The periosteum or scar tissue is sutured in place to lend slight pressure and help to prevent soft tissue absorption. The gelatinized bone mass can be molded with the fingers through the soft tissues. A slight pressure dressing (30 mm. Hg) is applied over the area.

Gelatinized bone has been used in sixty-five cases to reconstruct various skeletal defects about the face and the extremities. The great majority of these repairs have been carried out to correct loss of normal facial contour and good results were obtained in all but one instance. The unsatisfactory result occurred in an old ununited fracture of the mandible when some of the gelatinized bone became deposited just beneath the skin. Healing was satisfactory but the resulting scar was fixed and had an irregular surface. Later small bone spicules were extruded on the thirty-eighth and sixty-first day postoperatively. (Table 1.)

Repair of the supraorbital ridge defects was performed in eighteen cases. The loss was due to such trauma as gunshot wounds, automobile accidents and severe electrical burns. Two of the cases were repaired following extensive frontal sinus surgery. (Fig. 4A and B.)

Seven cases of malar depression were treated. In lieu of the cartilage introduction with the resultant scarring which was formerly employed, the gelatinized bone mass was injected through the hair-bearing skin of the temple. It was in this type of case that needle introduction was first attempted in the human. Of the twenty-seven cases of saddle nose deformity twenty-three were of traumatic origin while two were the result of tumor surgery and

TABLE 1
USE OF GELATINIZED BONE IN SIXTY-FIVE CASES

Location	Cause of Condition	Method of Repair	Length Postoperatively (mo.)	Type of Bone
Supraorbital Ridge (18 Cases)				
Unilateral (12)	Gunshot wound 4	Open method	87, 86, 86, 44	Autogenous
	Auto accident 7	2 open	40, 37	Autogenous 5
		5 needle and syringe	40, 33, 32, 17, 1½	Homogenous 2
	Severe electrical burn 1	Open	4	Autogenous
	Frontal sinus surgery 1	Needle and syringe	26	Autogenous
Bilateral (6)	Gunshot wound 1	Open	86	Homogeneous
	Auto accident 3	Open	42, 34, 7	Homogenous 2, autogenous 1
	Frontal sinus surgery 1	Needle and syringe	15	Homogenous
Malar Depression (7 Cases)				
Unilateral (6)	Auto accident 5	Needle and syringe	44, 37, 32, 21, 14	Autogenous
	Industrial accident 1	Needle and syringe	18	Homogenous
Bilateral (1)	Congenital 1	Needle and syringe	3	Homogenous
Saddle Nose (27 Cases)				
Traumatic	Trauma 22 (various types)	7 open	86, 44, 84, 41, 37, 13, 5	Autogenous
		15 needle and syringe	42–1	Autogenous
	Postoperative (tumors) 2	Open	81, 12	Autogenous
Infectious	Postinfectious syphilis	Needle and syringe	41, 30	Autogenous
	Tuberculosis	Needle and syringe	4	Autogenous
Mandibular Deformities (10 Cases)				
Micrognathism	Gunshot wound 1	Open	88	Autogenous
	Congenital 3	Needle and syringe (used nasal hump)	27, 17, 4	Autogenous
Unilateral (6)	Fracture 5	Open 1	11	Autogenous
		Needle and syringe 4	31, 27, 22, 9	Autogenous
	Tumor excision 1	Open	16	Autogenous
Long Bones (3 Cases)				
Femur				
Pin tract infection (1)	Fracture 1	Open but with needle	5	Homogenous
Knee (2)	Fracture 1	Needle and syringe	38	Homogenous
Arthrodesis	Tuberculosis 1	Needle and syringe	20	Autogenous

three were postinfectious, two syphilitic and 1 tuberculous. These cases were elected for correction with this material because it was not necessary to elevate the depressed elements in order to assure satisfactory nasal function. In the simpler type of case the gelatinized bone was introduced by injection; but where extensive scarring prevailed, particularly of the skin of the nasal dorsum where plastic surgery might be indicated, the open method was preferred. (Fig. 5A and B.)

The ten mandibular deformities were of two types. The bilateral cases, micrognathism, were due to absorption of the mandibular rami caused mainly by trauma except for three congenital cases. The remaining six

4A 4B

FIG. 4. A, Preoperative view of a supraorbital defect; B, the same defect repaired with gelatinized bone. (From *Brit. J. Plastic Surg.*, 2: 269–272, 1950.)

5A 5B

FIG. 5. A, Preoperative view of a saddle nose deformity following an auto accident; B, the same defect repaired with gelatinized bone. (From *Brit. J. Plastic Surg.*, 2: 269–272, 1950.)

had only one mandibular ramus involved, five in ununited fractures and one following excision of a tumor. Kirschner wire fixation was used in all instances.

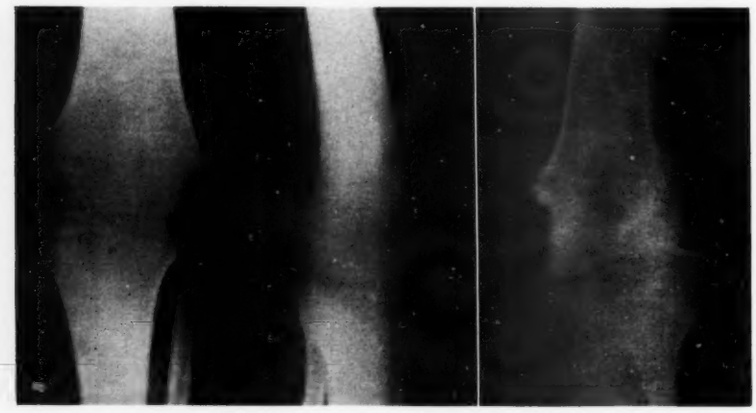
In all of the congenital micrognathics the nasal hump was removed, ground up and introduced into the mental region to correct optically the micrognathism as malocclusion was not too pertinent a feature. If marked malocclusion is present, a resection is required. (Fig. 6A and B.)

In one case of a pin tract infection of the upper femur following fixation for an intertrochanteric fracture there was extensive absorption. A homogenous bone peg was driven into the tract after the introduction of gelatinized bone. Healing of the tract appeared to be facilitated by the use of the gelatinized bone mixture.

Arthrodeses of the knees were created by needle injection of the bone mass. One was following a badly comminuted fracture of both femoral condyles complicated by dislocation of the knee. The joint cartilages were badly damaged. Gelatinized bone (homogenous, bank bone) was introduced and a solid fusion occurred. The second case was one of a tuberculous knee joint with bone absorption. It

6A 6B

FIG. 6. A, Preoperative view of congenital micrognathism with hump nose deformity associated; B, the same corrected with gelatinized bone made from the nasal hump.



7A 7B

FIG. 7. A, Fusion of knee with gelatinized bone; B, fracture occurring eleven months after fusion.

was believed that further removal of bone would shorten the limb too much. Autogenous gelatinized bone was introduced. This case is of interest for eleven months after the fusion a severe injury to the same knee was sustained. A fracture line occurred below the joint fusion thus illustrating the strength of the fusion. (Fig. 7A and B.)

SUMMARY

A review of the various substances that have been employed in the correction of skeletal defects reveals that none have proven wholly satisfactory. A preparation of gelatinized bone appears to be quite satisfactory. It is easily acquired from autogenous or homogenous sources. It appears to accelerate bone healing as much as 40 per cent. The complete explanation of this phenomenon is not entirely clear but results are due to one of five or a combination of all five factors previously discussed. The technic is simple and the introduction may be by needle or open method. Good results were obtained in sixty-five patients treated with this material.

It would seem that the foregoing described method with its stimulation and hastening of bone healing might be applied to delayed and ununited fractures.

Theoretically, rapid healing of simple closed

fractures might be enhanced but at the present stage of our investigations this suggestion is not warranted.

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DISCUSSION OF PAPERS BY DRS. MOSELEY, EVANS AND LEBOW, AND SWANKER AND WINFIELD

Herbert E. Pedersen (Detroit, Mich.): I would like to say just a few words about Dr. Evans' paper not because I am especially prepared to discuss the engineering principles involved but because I have had the opportunity to read his paper and likewise to talk to him many times as the work was performed.

Not very long ago in discussing two papers on the same subject which presented opposite conclusions Dr. Leroy Abbott stated that it seemed to him we would probably get answers which we were able to analyze more critically when research

teams included engineers. Dr. Evans has a research team which does include an engineer and all of his work has been done extremely carefully.

He has presented a great amount of detail which may be a little bit difficult to assimilate. Several things, however, I think are rather important. First there is evidence that dry bone does not have the energy-absorbing capacity of wet bone. Second, there is other evidence to indicate that wet bone (wet dead bone) does not have the energy-absorbing capacity of fresh living bone. Also, he has demonstrated that per unit area of bone there are many regional differences within the same bone.

All of these things point, I think, to the fact that as related to the transmission of forces, the part of the bone which is of most importance and which probably has been neglected the most in the past is the ground substance. Most of the research which has been done has dealt with chemical analyses and discussion of the chemicals themselves. Probably we should spend more time discussing ground substance.

HARRISON L. MCLAUGHLIN (New York, N.Y.): I would like to speak about Dr. Moseley's presentation and about his film. The clinical significances of the inferior approaches to the shoulder joint should be kept in mind. Dr. Moseley has emphasized one of them, namely, the differing locations of the various structures that we are acquainted with according to the position of the arm. I was particularly impressed by the rather peculiar position of the axillary nerve with the arm in hyperabduction.

Somewhere between 5 and 10 per cent of primary dislocations show a contusion or stretching injury of this nerve. We used to think that such nerve lesions were the result of bad treatment or neglect. We now find that our nerve complications—and most of them have been of the axillary—occurred in dislocations which were made possible by a disruption of the posterior supports of the joint. As Dr. Moseley illustrated, when the anterior capsule and glenohumeral ligaments are intact and the humerus simply rolls out of the joint with the glenohumeral ligaments acting as a hinge, there is no place for it to go except down into and to contuse the brachial plexus.

By implication Dr. Moseley suggested that in the past infected shoulders have been drained through the axillary route. I wonder if we should drain shoulders through the axilla. I have seen a couple of patients who were drained in this manner and they did not enjoy the deep, hard, adherent scar which rubbed constantly under their armpit. Neither did one of them, who had a definite brachial plexus compression by infection, enjoy his paralyses and disturbed sensory findings. I think shoulder joint infections can be handled from on top, in front or behind and do not require gravity drainage as a general rule.

Dr. Moseley said that the present antibiotic and chemotherapeutic era now allowed us to go into uninfected shoulders from the axilla. I doubt that this route is much more dangerous than any other. Whether or not it is used might better be determined on another basis than the risk of infection.

EDWARD A. KITLOWSKI (Baltimore, Md.): Dr. Swanker's presentation intrigues me no end. The raising of periosteum on depressed bone is no simpler than raising the periosteum on bones that are not depressed and the space that one gets will never suffice to fill the depression out if it is of sufficient size to justify the operation.

My impression of saddle noses primarily is this: You will get a depressed fracture of your septum, primarily a fracturing of your septal cartilage from your bony septum. Where does Dr. Swanker put this substance, in underneath periosteum in that area to secure the beautiful result that he attained? It must go in the soft parts.

Another thing that we are finding out—preserved bone, preserved cartilage naturally picks up sooner or later. I have seen cases in which pieces of preserved cartilage have been picked up twice in the same individual, each time in one year. It was repeated the second time and this boy, at the end of the first year, had none left. Again at the end of the second year there was absolutely none left. We are finding out that preserved and homogeneous material is definitely replaced. If it is a small enough defect so that the replacement by fibrous tissue is sufficient, we are not too concerned; but if not, it simply means that one sooner or later has to go back and do the same thing. It may take one year or it may take five for the absorption of this material.

H. F. MOSELEY (closing): If I may answer Dr. McLaughlin's question, the only reason for the mention of drainage through the axilla was that when we first carried out this study people told us this was not a new approach. We quite agree it is not. We do not drain the shoulder through the axilla; the reference was purely historical.

With reference to the possibility of infection, I do not think there is any comparison between the safety without antibiotics and chemotherapy between the anterior, superior, posterior and lateral exposures compared with that through the axilla. Even with the help of chemotherapeutic agents, I would not use the axillary approach on the short type of individual with a sweated and hairy axilla. The cases must be carefully selected and usually this exposure is for the female patient who refuses to have an operation which will give her a conspicuous scar on the shoulder. Two of our cases have been recurrent dislocations in females selected for that reason. In summary, I believe

you must do a very careful preoperative preparation of the skin and you must afford the patients protection from infection by antibiotics.

WILSON A. SWANKER (closing): I would like to answer Dr. Kitlowski if I may. With saddle noses it is natural that these cases have to be chosen. Any case in which there is any type of vestibular or fossal obstruction would not be suitable and this technic would not be usable.

As far as getting it under the periosteum is concerned, in case I showed this was not done by the needle and syringe method; it was done by open method. There was a terrific amount of scar tissue here and this was probably placed in the scar tissue.

I did not mention it in the paper but apparently if this gelatinized bone is not placed either in close contact with fibrous tissue or periosteum, it is readily absorbed. In the soft tissue and muscle in experimental animals this material is absorbed in from three weeks to a month. In a few cases in which I have been unfortunate enough to get some in the soft tissue (which will happen once in a while) we have had absorption. In one case in which I operated upon a mandibular deformity and tried to obliterate a large defect on the side I got some in the incision, apparently just underneath the skin, and a couple of small pieces came out. The incision healed but it did not have the beautiful scar it would have had otherwise.

RECONSTRUCTION OF INJURIES FOLLOWING EXCESSIVE RADIATION THERAPY*

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MUCH has been known about the hazards of overexposure to radium and roentgen rays for many years. In spite of this knowledge and in spite of repeated teachings the repair of injuries of this nature continues to be one of the major items in the practice of all plastic surgeons. It is not a subject of local importance but one of international scope. These complications frequently produce tragic results, not only as local deformities but also many patients are driven to morphine addiction in their effort to obtain relief from the severe pain and itching that is ever present. Also, many developmental deformities are seen following irradiation over the epiphysis of growing children, which naturally causes arrest of growth.

The origin of radiation injuries does not always follow the same pattern. Many arise as incidental by-products in the necessary roentgen therapy of underlying or deeper malignant disease. Others follow overzealous treatment of cutaneous lesions that might well have been treated more judiciously by surgical excision from the onset. Another group arises following treatment by conscientious physicians who have not been trained properly in administration or who are not aware of the potential hazards involved. Severe damage may also arise following treatment of a person whose skin is unusually susceptible or from the effect of an x-ray machine that has not been properly calibrated. I have been impressed by my observation of several patients who have sought plastic surgical repair who had received roentgen therapy as long as fifty years previously only to have ulceration and carcinomatous degeneration occur after this long period of time. Conversely, I have seen one patient who had squamous cell degeneration of an acute x-ray ulcer that followed six months after excessive therapy for simple basal cell carcinoma of the skin over the ankle. Such observations are not surprising, however, when one remembers that the endarteritis of the underlying vessels is an irreversible process and this, plus normal arteriosclerotic changes in the vessels, is bound to arrive at a state of diminished local nutrition so that breakdown becomes inevitable.

However, when comparing the vast number of radiation treatments that are given, the actual total of injuries is relatively small. But to the plastic surgeon who sees patients with such injuries the number seems to be entirely too large. Furthermore, these patients comprise an important group because of their disabilities which arise from the discomfort associated with the condition. Because of this one cannot emphasize too greatly the seriousness of the problem. When radiation therapy is indicated, it must be given only by an expert trained in its proper administration.

One still sees x-ray dermatitis and necrosis from the "Tricho" system that was popular many years ago for removal of superfluous hair. Likewise, we see attempts made to destroy hair even now by the use of x-ray therapy. It is a well known fact that must be stressed again, that in order to remove hair by such procedures it is also necessary to produce radiation damage to the involved area of skin!

Symptoms. Severe pain, itching and finally ulceration are the typical subjective symptoms of chronic radiation dermatitis. These symptoms are frequently so severe that they produce addiction to the use of opiates in an attempt to secure palliative relief. Permanent alleviation, however, cannot be obtained until all of the damaged tissue has been excised. Following radical surgical excision complete relief is dramatic and permanent cure can be anticipated as soon as the defect created by the surgical excision has been closed.

Objectively, one will note atrophy, telangiectasia and some minor contractures of the skin. As found in other cutaneous lesions associ-

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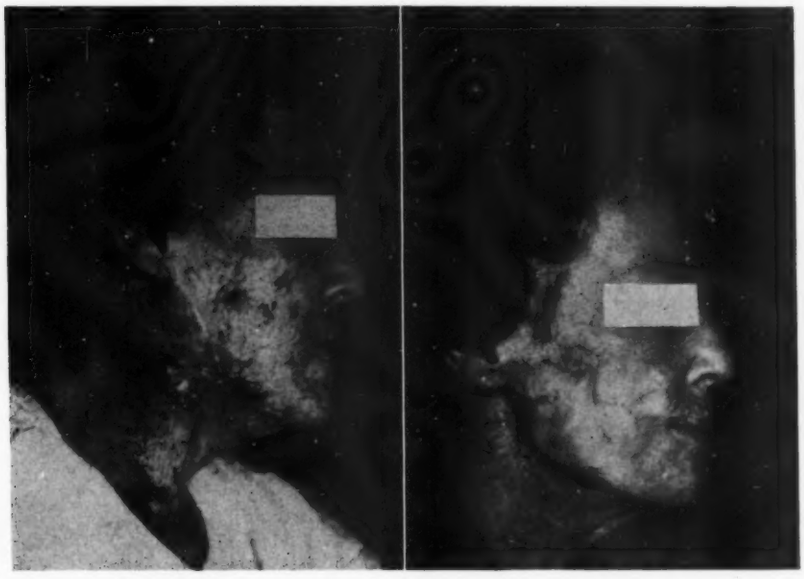


1A 1B

FIG. 1. A, Extensive x-ray dermatitis of face with necrosis and squamous cell carcinomatous degeneration in two areas. Entire mass excised and replaced with thick split thickness skin grafts. B, result three years later.

2A 2B 2C

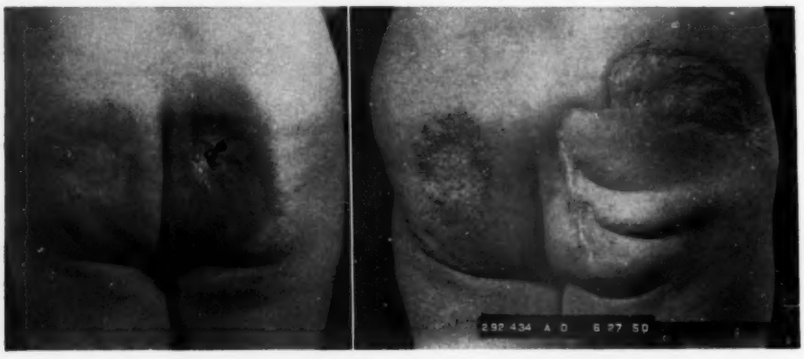
FIG. 2. A, Radium dermatitis and necrosis following therapy for carcinoma of parotid twenty-five years before. Tubed flap has been prepared on neck. B, flap has been transferred following excision of damaged tissues. C, flap has been divided and adjusted. A portion of the excess was utilized to construct a new ear lobule while the balance was returned to the neck.

ated with avascularity, chronic ulceration and carcinomatous degeneration are not infrequent. My own cases show that approximately 50 per cent have degenerated into squamous cell carcinoma. Undoubtedly this figure would be even higher if the chronic radiation ulcers were permitted to remain for longer periods of time without excision. I have one case in wdich the lesion degenerated into a spindle cell sarcoma.

Patbology. Typical changes are produced by radiation. The essential finding is obliterative arteritis or hyalinization of the vessels in the damaged area. This is an irreversible obliterative process that is seen in the arteries, veins,

3A 3B 3C

FIG. 3. A, Radium dermatitis with necrosis and squamous cell carcinomatous degeneration of the ulcers. This followed treatment fourteen years ago for metastatic supraclavicular metastasis after radical mastectomy for cancer of the breast. B, after excision of the damaged tissues, a direct flap was rotated forward from the supra-scapular area. The donor site was covered with a split skin graft. C, final result after one year. It is of interest to note that this patient has not had a recurrence of her cancer of the breast.



4A 4B

FIG. 4. A, Deep x-ray necrosis and dermatitis of right buttock following post-operative roentgen therapy for cancer of the uterus. The same amount of therapy has been given through the left buttock but, curiously, this side has not broken down. B, after wide excision down to the ischial tuberosity the surgical defect was covered with a large rotation flap from the lateral aspect of the buttock. The donor site was covered with a split skin graft. This result is five years old.

5A 5B 5C

FIG. 5. A, Severe x-ray dermatitis and necrosis following excessive treatment for plantar wart one year before. B, damaged tissues excised down to underlying tendons and bone. Defect covered with pedicle flap from opposite leg. C, result one year after division of flap. Because of potential trauma from weight bearing flaps on the sole of the foot must be guarded very closely until sensation returns, usually in twelve to twenty-four months.

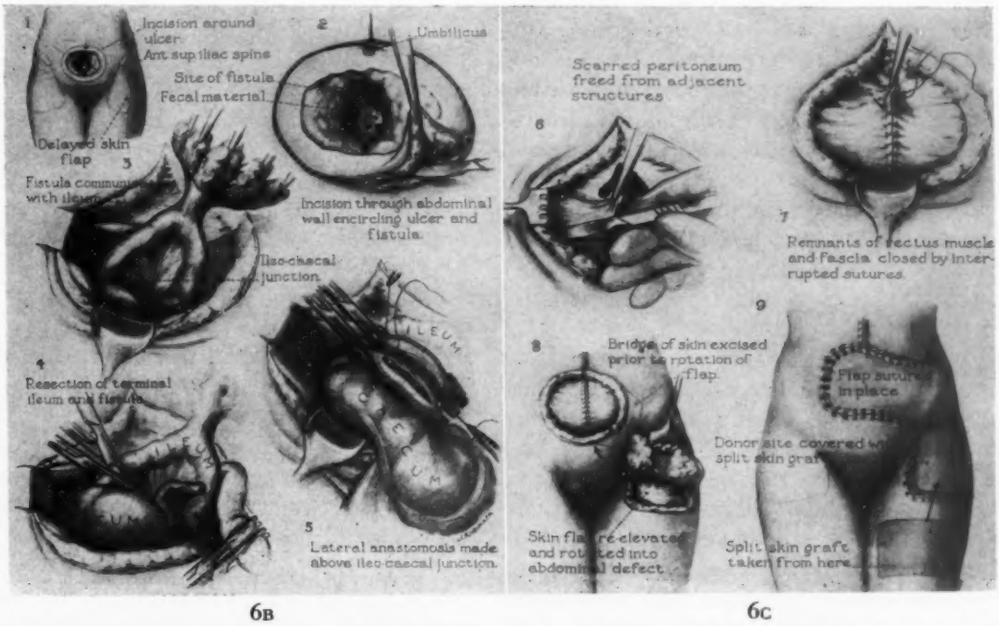
capillaries and lymph vessels and which produces interference in the nutrition of the affected tissues. White necrosis or anemic gangrene occurs eventually which finally results in ulceration. The area is left with poor circulation which tends to become worse with the passage of time. A gelatinous membrane develops over the underlying painful ulcer. The surrounding tissues become fibrotic and if of sufficient magnitude may extend into the adjacent muscles, tendons and bone. Telangiectasia, pigmentation, atrophy, thickening and keratosis develop in the surrounding skin, the rate of progress being dependent upon the degree of endarteritis present.

Finally, a certain percentage of lesions degenerate into squamous cell carcinoma. It is not uncommon to see an over-radiated basal cell carcinoma of the skin break down into a chronic radiation ulcer and this in turn into a squamous cell carcinoma. Such a complication obviously cannot be treated by further roentgen ray therapy but must be excised.

TREATMENT

When one considers the avascularity produced in the pathogenesis of a radiation injury, it becomes evident that there is little place for

FIG. 6. A, This is an unusual case of a patient who received postoperative deep x-ray therapy following surgery for carcinoma of the uterus. Ten years later the anterior abdominal wall broke down, forming a typical deep x-ray ulcer. One year before admission to our service a small bowel fecal fistula broke through the base of the ulcer. Prior to excision of the ulcer and fecal fistula two flaps were "delayed" downward over either thigh.



6B 6C

FIG. 6. B, The x-ray ulcer and fecal fistula were excised and a lateral anastomosis made between the terminal ileum and cecum. C, the wound was then closed as shown. Only one of the previously prepared flaps was needed to cover the defect. (Note: The bowel surgery in this case was performed by Dr. Warren H. Cole.)

conservative management of this lesion. In spite of enthusiastic reports given by the advocates of local applications of radon paste or the aloe vera leaf, I have yet to see any patient who has ever responded permanently to such simple management. Furthermore, when one considers the pathology involved, permanent cure can be anticipated only when all the damaged tissue has been excised back into an area of good blood supply. This level is sometimes difficult to estimate, but one should always err on the side of being too radical. If the excision is not wide enough, future reconstructive operations will fail since later degeneration will occur around and below the site of the original excision. It should be emphasized again that the severe pain and itching are relieved as soon as all of the damaged tissues have been excised. In fact, more than one case of morphine addiction has been cured at this dramatic point.

After surgical excision has been completed, the remaining problem is then one of reconstruction of the resultant cutaneous defect. A few areas may be closed by primary suture after adequate undermining of the border flaps so that they can be mobilized without tension. The majority of cutaneous defects will, because of their nature and size, have to be covered with a skin graft or a skin flap. The choice of either will be guided largely by the residual blood supply and contents of the surgical defect. Because of its comparative simplicity a primary split-thickness skin graft may be applied over the area. In certain borderline problems, and this usually entails considerable clinical judgment on the part of the surgeon, the defect may be allowed first to fill in with granulation tissue, following which a split-thickness skin graft may be applied. (Figs. 1 to 6.)

In cases in which the surgical excision has left exposed tendons, nerves, bone or large blood vessels, or if the defect is of questionable viability, a skin flap of some type must be utilized. A previously tubed skin flap taken from a distant point is ordinarily reliable but entails long, tedious operative steps. Ideally, when the tissues are available, the defect can be closed easily with a large direct flap that has been rotated in from the border of the area. In certain lesions on the face the donor site has been closed by primary suture, which gives an ideal cosmetic result with matching face skin. In other areas, where the adjacent skin is relatively inelastic, the donor site is covered with a split-thickness skin graft. This type of repair has been most satisfactory because it covers the open wound permanently and quickly with a minimum amount of discomfort or loss of time to the patient.

CONCLUSIONS

1. A surprisingly large number of radiation injuries still occur in spite of present knowledge of roentgen ray and radium therapy.

2. Roentgen and radium rays produce irreversible reactions that are characterized by severe pain, itching, ulceration and eventual degeneration into squamous cell carcinoma.

3. The distressing symptoms of radiation injuries can be cured surgically by wide excision followed with closure of the resulting defect by one of several different plastic surgical procedures.

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RECONSTRUCTION OF THE THUMB*

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TOTAL loss of a thumb, fortunately an uncommon industrial injury, produces a most serious disability, equalling in compensability the loss of half the hand. Such a loss demands reconstruction of a functionally satisfactory substitute which is cosmetically acceptable. The requirement for such a satisfactory thumb substitute is that it be capable of a fair degree of skill and power in pinching, grasping and opposition, the fundamentals of thumb mechanics. It must be either opposable itself or capable of having the other fingers of the hand opposed to it. It must be possessed of sufficient sensation so that clumsiness and trophic ulceration are avoided, and a certain degree of tactile discrimination is retained.

In general, there are two main methods of thumb reconstruction. The choice depends on the presence or absence of a proximal segment of intact thumb metacarpal with attached remnants of innervated intrinsic thenar muscles capable of moving it.[1] In the absence of such a useful remnant reconstruction must be total. This involves transplantation to the thenar area of a digit, usually the index, with its nerve, blood and tendon supply intact.[1–4] Certain modifications of the transplanted digit then follow, such as rotation osteotomy to shorten the reconstructed thumb and ensure opposability. A period of re-education and exercise follows, often long and discouraging, in order to train the newly transplanted and modified member to function as thumb rather than finger. Originally it was believed that only a damaged index finger should be thus utilized.[6] With realization of the satisfactory substitution afforded by the middle or even the ring finger for index function, it is thought permissible under certain circumstances to transplant the uninjured index finger to serve as a thumb.[1] Usually the adjacent index finger is thus transplanted or "pollicized." However, for the sake of completeness it is necessary to mention transplantation of the opposite index finger which mutilates the opposite hand,[2] and Nicoladoni's operation of transplantation of a toe, usually the great toe, which cripples the foot and imposes a torturing position during the period of take.[2,9] Both latter methods provide a functionally inadequate and sensorially deprived thumb-effigy, rather than a capable substitute and are rarely employed.

The technic of pollicization of the index finger is outlined in Figures 1 to 3.

In the presence of a useful remnant of the thumb metacarpal, reconstruction follows different lines and embodies elongation of the stump by means of local or transplanted flaps, with implantation of a bone or cartilage peg for rigidity. In this type of reconstruction several factors present themselves. To be mechanically effective the reconstructed thumb must be long enough to extend to the metacarpophalangeal joint of the index or adjacent remaining finger and must be possessed of sufficient rigidity. It must be sensitive enough to impart some degree of skill, tactile discrimination and crude stereognosis to such fundamental thumb functions as pinching and grasping, and to avoid repeated trophic wear and ulceration.

Local flaps have been recommended by Sir Harold Gillies and others who have recognized the disadvantages of a partially anesthetic stump and believed that locally innervated flaps possessed a great advantage in this respect. Simplicity and quickness are other advantages, the entire reconstructive program sometimes being completed in one stage. Unfortunately, the thumb substitute thus produced is somewhat mechanically clumsy and unsightly and may be too short, even after deepening of the thumb cleft by phalangization.[5] The technic of thumb reconstruction by this method (cocked hat flap) is shown in Figures 4 and 5.

The last method to be discussed is elongation of the thumb remnant by means of a tubed

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pedicle flap, stiffened internally by a bone or cartilage peg. Additional lengthening or shaping may be secured if necessary by deepening the thumb cleft between metacarpal 1 and the next adjacent metacarpal carefully preserving the blood and nerve supply and the remaining attached intrinsic musculature. The cleft thus produced is lined with a thick split skin graft or pedicle flap. Even in the absence of a useful mobile stump, a serviceable rigid "post" may be fashioned in this way to which the remaining digits may be opposed to provide fairly good function.

Although the thumb thus produced can be made of any length, two limitations should be observed: (1) For adequate mechanical efficiency the thumb substitute need be only as long as the metacarpophalangeal joint of the adjacent digit. (2) The length of the transplanted tube should not be much over 1 inch to allow for sensory reinnervation from the thenar bed to develop. It is a mistake to make the reconstructed thumb too long in an effort to provide complete dimensional or cosmetic restoration. In such cases, if this is done, one is likely to encounter the complications of

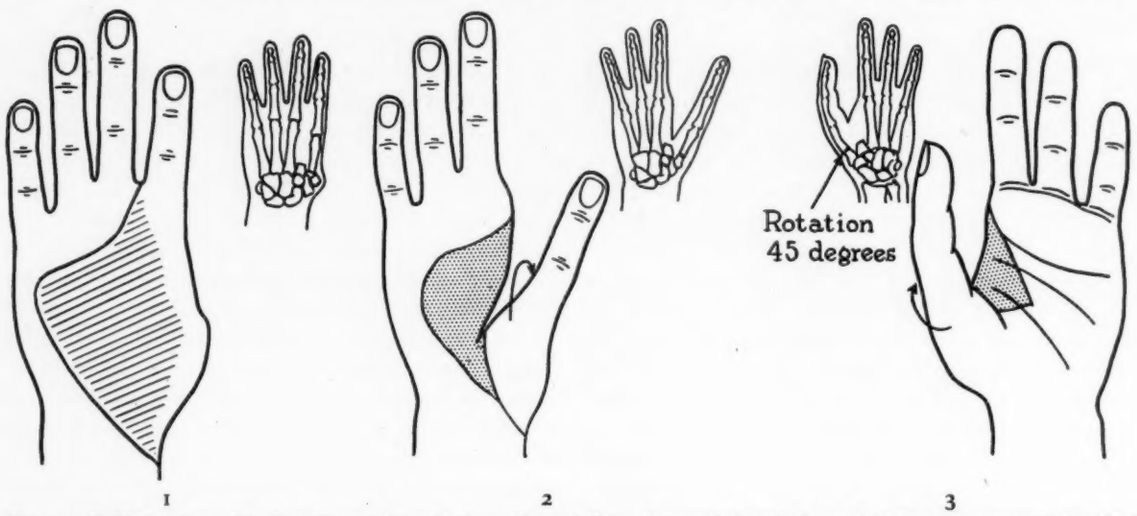


FIG. 1. Pollicization of index finger, dorsal view. Dorsal flap elevated (shaded area) index metacarpal divided near base (which is left to preserve width of palm) and displaced downward toward base of thumb metacarpal.
FIG. 2. Pollicization of index finger, dorsal view. Cleft between metacarpals 2 and 3 developed, deepened, lined on index side with previously elevated dorsal flap; on opposite side by thick split-skin graft (shaded area).
FIG. 3. Pollicization of index finger, volar view. Rotation osteotomy of index metacarpal to ensure opposition of newly formed "thumb." It is usually advisable to perform this as a separate stage. Any shortening required may be done at this time, also.

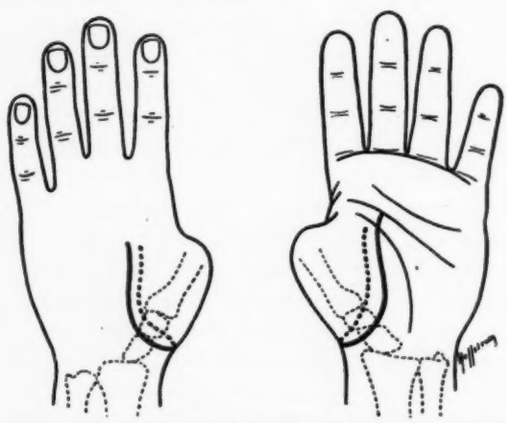


FIG. 4. Gillies' "cocked hat flap" technic; outline of flap continuous from volar to dorsal surface as shown by heavy solid and dotted lines.

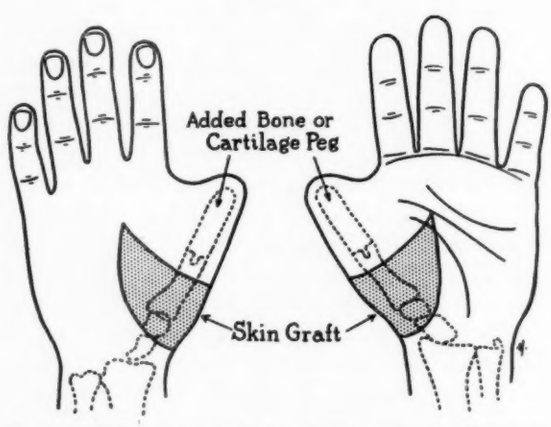
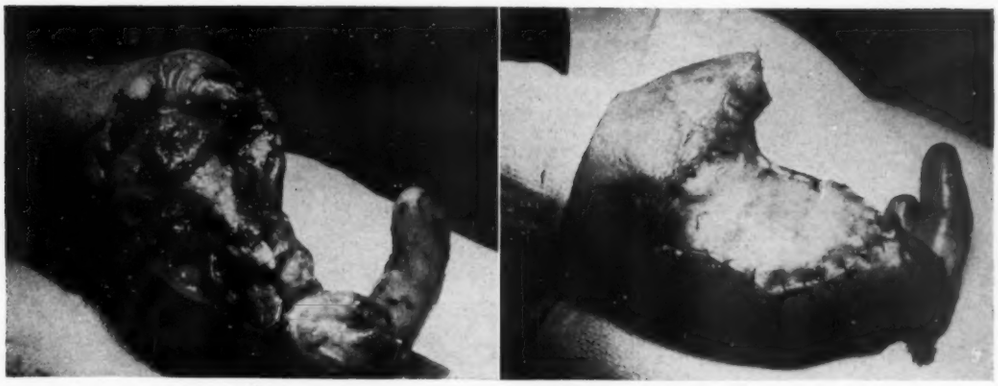


FIG. 5. Gillies' "cocked hat flap" technic. Flap elevated and advanced; defect filled by thick split-skin graft; bone peg inserted.



6 7

FIG. 6. Thumb reconstruction by means of tubed pedicle flap (Case R. G.); original defect after conservative débridement.

FIG. 7. After closure by developing local flaps and free grafting; note thumb rudiment (Case R. G.).

recurrent ulceration of the tip of the tube or fracture or aseptic necrosis and absorption of the long bone peg needed to support the long tube.[6] If short tubes are used, it will be found that cartilage pegs will be quite adequate for support. If cartilage is used, time is not wasted waiting for bony union and there will be less uncertainty about necrosis and absorption of the peg. Short pegs can be inserted into the metacarpal stump and fixed with a steel suture at the time of transfer of the tubed pedicle flap with less over-all impairment to the blood supply of the tube and consequently less chance of later distal necrosis of the tube when it is detached, shaped and shortened.

FIG. 8. Deepening of thumb cleft (phalangization) and lining with thick split-skin graft, dorsal view (Case R. G.).

CASE HISTORY

R. G., a twenty-six year old machine operator, received a mangling injury to his right hand from a 190 ton Minster press. On admission to the hospital it was seen that the entire right thumb had been avulsed along with the right index and all but a tiny remnant of the right mid-finger. There were compound comminuted fractures of metacarpals 2, 3, and 4 and of the proximal phalanx of the fourth finger. About one-third of the thumb metacarpal with attached and innervated thenar muscle remnants remained. After careful conservative débridement a survey of the situation revealed a small but useful thumb stump in the retained fragment of the first metacarpal, complete loss of the index, almost complete loss of the middle finger with such damage to the corresponding metacarpal and adjacent vessels and nerves as to make salvage doubtful and use for transposition impossible. The plan of reconstruction embraced rehabilitation of fingers 4 and 5, preservation of the thumb stump with elongation by phalangization, and the later addition of a cartilage peg-stiffened pedicle flap for additional length to construct a functioning thumb substitute capable of a moderate degree of intrinsic motion and some degree of opposition.

Total reconstruction covered intermittently a period of fourteen months and embodied four phases: (1) Débridement and primary closure of hand remnant with simultaneous construction of an abdominal tubed pedicle (Figs. 6 and 7); (2) phalangization of the thumb cleft, removing metacarpal 2 and all but base of metacarpal 3, and lining cleft with thick split skin graft and with skin from fileted stump of mid-finger (Figs. 8 and 9); (3) simultaneous insertion of costal cartilage peg and attachment of abdominal tube to thumb stump (Fig. (10); (4) detachment, shortening and shaping of abdominal tube to form new thumb (Fig. 11.)

Between stages the patient was returned to work at carefully selected jobs to preserve and augment function and skill in the hand. Physiotherapy was also employed to the utmost between all stages of

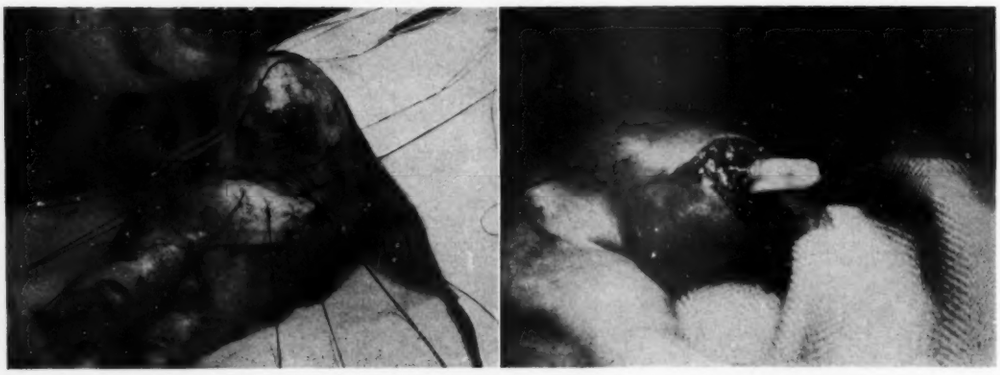


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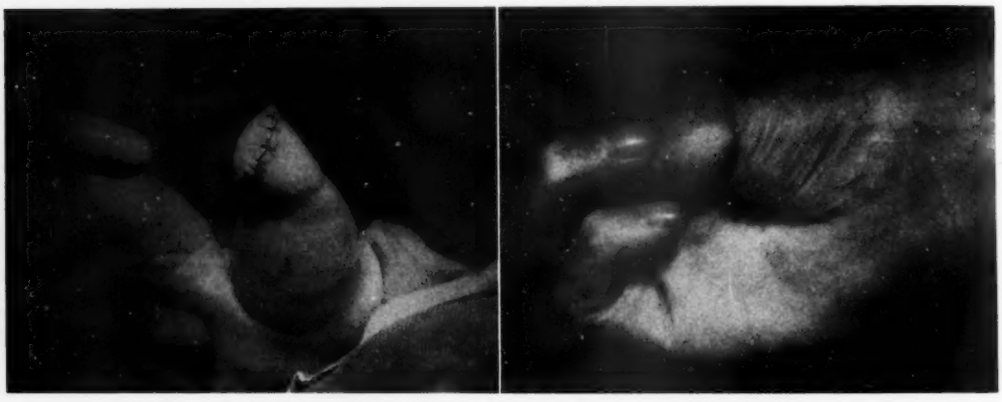
FIG. 9. Phalangization, volar view (Case R. G.).
FIG. 10. Costal cartilage peg inserted and fixed with steel wire suture into exposed base of thumb metacarpal (Case R. G.).



11 12

FIG. 11. Shaping and shortening, placing suture line laterally to avoid bearing surface (Case R. G.).
FIG. 12. Thumb reconstruction; opposition and adduction (Case R. G.).

13 14

FIGS. 13 and 14. Thumb function (Case R. G.).

the repair. The cooperation and morale of the patient were excellent and contributed greatly to the final result. At the end of a year and a half of hard use of the reconstructed thumb no signs of ulceration or trophic change have appeared, and remarkable degrees of sensation, tactile discrimination and skill have developed in the member. The usual manual dexterity required by modern life has been restored. The patient is able to dress himself and to perform such skilled tasks as writing and machine operating. (Figs. 12 to 15.)

FIG. 15. After a year and a half of hard usage; note absence of trophic ulceration (Case R. G.).

SUMMARY

Total loss of the thumb, an uncommon and crippling injury, demands reconstruction of a substitute that will be possessed of a fair degree of functional skill and sensation and which will be cosmetically acceptable. Choice of a method of reconstruction depends largely on the presence or absence of a useful and functional thumb stump remnant and is qualified also by the individual's status in economic life as regards acquired skills and occupations.

If no useful stump remains, an adjacent digit, usually the index or lacking this the mid-finger, can be transposed or "pollicized" with its nerve, tendon and blood supply intact, making a useful and sensorially intact substitute which, however, requires considerable re-education. If a useful stump remains, it should be judiciously elongated by one of several maneuvers or combinations thereof. The length of the reconstructed member need reach only to the metacarpophalangeal joint of the adjacent digit to be mechanically effective. Certain complications such as trophic ulceration, vascular impairment and sensory inadequacy result from excessive length of the thumb segment.

A case of total thumb loss in which a satisfactory substitute was reconstructed by a combination of phalangization and pedicle flap transfer is presented.

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EXPERIMENTAL CUTANEOUS GRAFTS TO LITTER MATE ANIMALS*

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WITH the advent of the atom bomb and the prospect of mass casualties, including thousands of severe burns, the interest of investigators in the fate of cutaneous homografts has been renewed. The obvious advantage of being able to use large homografts in the treatment of mass casualties needs no comment. It has been demonstrated by the author and many other observers that autogenous skin may be preserved by refrigeration or freezing for several weeks and transplanted successfully, with somewhat less than perfect "takes." If homografts could be made to survive permanently, skin banks would be a possibility. That is, however, not the case. With the exception of a few well authenticated instances of successful cutaneous homografts recorded in the literature, by far the majority of such grafts in man or adult experimental animals survive only a matter of days, or at the most a few weeks. Some of the factors which may influence the survival of the homografts will be mentioned subsequently.

Investigators have given scant attention in their published reports to the study of homografts between litter mate animals. It is for that reason that the following incomplete and somewhat inconclusive observations are recorded.

METHODS

The common types of cutaneous grafts employed in experimental animals have been small deep grafts or stamp size grafts, placed upon denuded surface areas. Their success or failure has been judged variously by gross visible or microscopic evidence of survival, proliferation of graft margins, direction and color of hair, persistence of characteristic pigmentation, and in some cases by tissue culture. Grafts applied to the surface of any experimental animal are exposed to conditions difficult to control, being impossible to protect completely, and their survival is even more difficult to evaluate objectively.

In order to obviate these objections the author employs pocket grafts constructed after the Esser inlay principle. The cutaneous graft cut with a razor or dermatome is wrapped about a thin sheet of dental compound, deep surface on the outside. This graft-covered stent is buried in a subcutaneous pocket, preferably in the paravertebral area of the animal, and is held in place by two or three fine sutures. The dental wax stent is removed when the sutures are, usually at from four to fourteen days. Secretion of the skin glands of the puppy grafts is so profuse that it is necessary to open the pocket early to avoid excessive edema and pressure necrosis. Young rats, on the other hand, will tolerate the presence of the foreign body for several weeks. The skin graft pockets so produced are accessible to frequent observation, without anesthesia, and lend themselves well to removal of a portion of the pocket for microscopic study, without damaging the remainder of the graft. These pockets may remain indefinitely and present incontrovertible evidence of the survival or failure of the graft. If the surface opening of the pocket is allowed to close, a skin graft cyst will result. (Fig. 1.) If the pocket is opened widely, it will gradually flatten out and become a part of the surface skin where it is more difficult to identify.

Thickness of the grafts seems to make little difference in the percentage of "takes." In puppies it is possible to cut fairly thin grafts, but in the thinner skinned baby rats the grafts are usually practically full thickness. Infiltration of the skin with procaine facilitates cutting the grafts. General anesthesia is seldom required. The small dermatome is ideal for cutting grafts from small rats whose thin, mobile skin is difficult to shave. If the fine hair is merely clipped with scissors over the

* This work was done in part in the Laboratories of the Department of Surgery, School of Medicine of Western Reserve University, the Fourth General Hospital, and St. Luke's Hospital, Cleveland, O.

donor site, the remaining hair sticks to the cement on the dermatome drum, leaving the graft fairly hairless.

GRAFTS BETWEEN LITTER MATE ANIMALS

Employing litters of mongrel puppies, cutaneous cross grafts were performed between all members of the litter, when the animals were three or four weeks old. The percentage of successful takes throughout the litters ran between 80 per cent and 100 per cent. At the same time similar grafts were performed between non-litter mates of approximately the same age. These were almost uniformly unsuccessful. In rare instances, however, the grafts between young non-litter mates vascularized and persisted. The procedure was repeated every four to six weeks. Because of the high mortality from distemper among puppies living under laboratory conditions, none of the litters remained complete for as long as six months, but observations were continued upon the survivors for as long as one year. Some of the original pockets were observed to persist for the entire period of observation. At an age which has not been determined, but somewhere between four and six months, the survivors among the litter mate puppies developed intolerance to the skin of other members of the litter. In other words, cross grafts from animals which were formerly compatible were now incompatible. No effort was made to determine the exact survival time of the grafts which failed to "take." There are so many uncertain factors in determining exactly when the graft is dead, that such determinations are considered of doubtful significance. It was interesting to note that the original graft pockets survived even though subsequent transplants were not tolerated by the recipient animal.

We had previously made unsuccessful attempts to alter the incompatibility of grafts between adult animals by injection of tissue suspensions or extracts, preserving the grafts in recipient serum, and regrafting at various stages of the tissue reaction to the incompatible graft, as has been done by others. Some of these were repeated without effect upon some of the litter mate animals which had developed incompatibility.

Since it seemed desirable to utilize animals less susceptible to disease under laboratory conditions, rabbit litters were employed for a small series of cross grafts while the author was overseas during World War II. The results in this small series were generally comparable to those previously observed in puppies. Long term follow-up of the animals was interrupted by military necessity. At the present time further studies are in progress upon litters of young rats. After a period of adapting technic to much smaller animals, the results thus far have been comparable to those previously described.

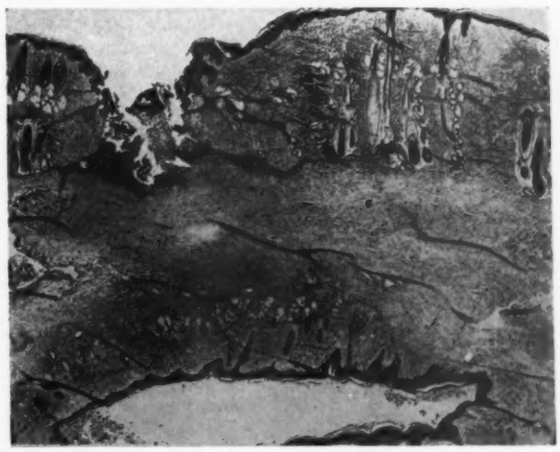

FIG. 1. Low power photomicrograph of a litter mate cross graft at four weeks. The cutaneous opening of the pocket graft has practically closed and the buried graft has formed a cyst.

HISTOLOGIC EVIDENCE

The photomicrographs shown in Figures 2 to 9 show fairly typical examples of the course of successful and unsuccessful grafts. The course of compatible litter mate grafts is identical with that of autogenous grafts. The status of the fresh graft at two days is shown in Figure 2. There is marked round cell infiltration evident in the zone between the graft and its bed, with no evidence of vascularization or proliferative activity by the elements of the graft. The nuclei of the epidermal layers are deeply stained, and the keratinized surface layers are separating. At five days (Fig. 3) the round cell infiltration (chiefly lymphocytes and plasma cells) has extended to the epidermis, and the superficial layers are being shed. At the same time there is beginning proliferative activity among the basal layers of epidermal cells, especially in the deeper hair follicles; some small blood vessels and new fibroblasts are apparent in the corium. At seven days (Fig. 4) the cellular reaction

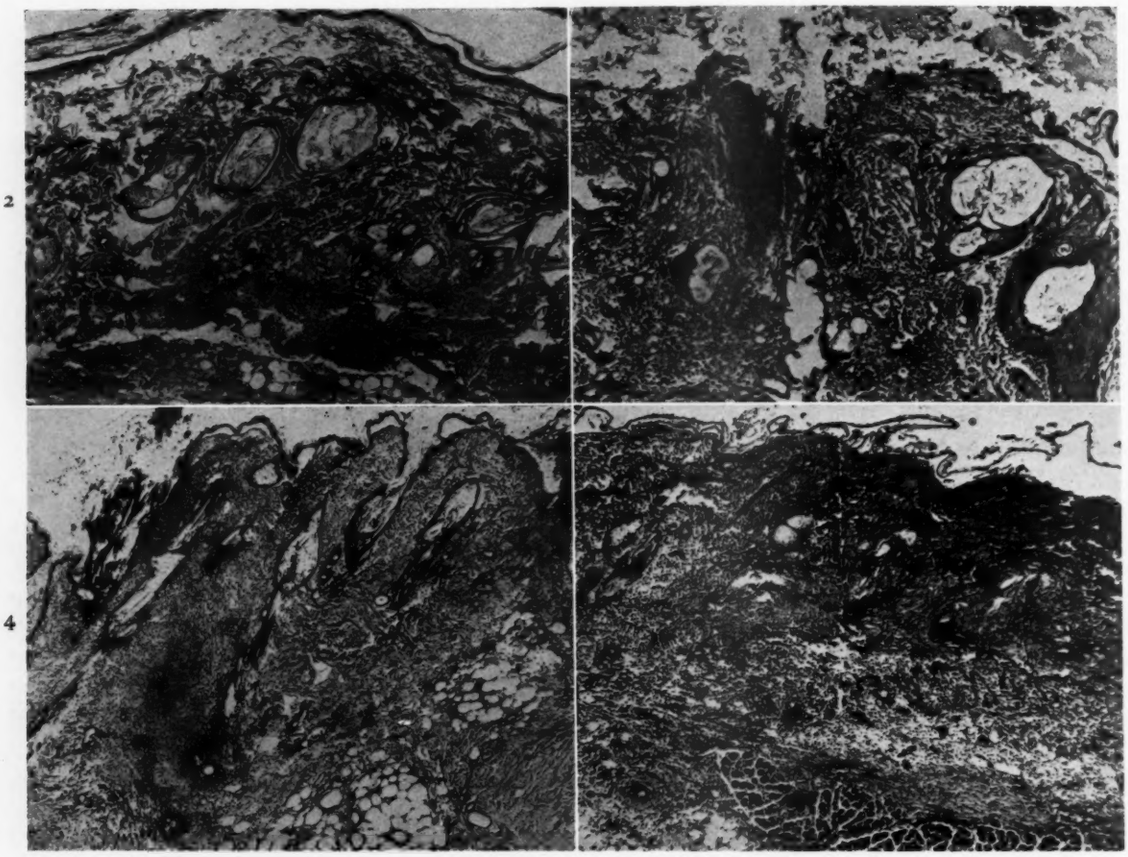

FIG. 2. Litter mate (puppy) graft at two days; the marked round cell infiltration between the graft and its bed is obvious. The epidermal cells are showing no evidence of proliferation, and there is no vascularization of the deeper layers. The epidermal nuclei are pyknotic and superficial layers are beginning to desquamate.
FIG. 3. Litter mate (puppy) graft at five days; cellular infiltration has increased, but there is now some evidence of beginning vascularization and epidermal proliferation.
FIG. 4. Litter mate (puppy) graft at seven days. Higher power magnification showing marked cellular reaction, but beginning organization, greater vascularity and marked epidermal proliferation.
FIG. 5. Non-litter mate (puppy) graft at nine days. The extreme degree of round cell infiltration has invaded the epidermis; no vascularization is apparent; the superficial layers are necrotic and about to be cast off.

is at its peak, but marked proliferative changes among the epidermal cells is apparent. Up to the interval between five and seven days, the courses of the compatible and the incompatible graft are almost identical. From that point on, however, the incompatible graft shows no evidence of vascularization, the cellular infiltration increases and the epidermal elements show no tendency to proliferate. Many polymorphonuclears enter the infiltrate, and the entire graft becomes necrotic (Fig. 5 at nine days), and is then gradually liquified or shed, a process that is usually complete in about fourteen days. The compatible graft, on the other hand, shows progressive increase of fibroplasia and epidermal hyperplasia. The latter is sometimes so wild as to resemble neoplasia. (Fig. 6.) Gradually the cellular infiltration is replaced by fibroblasts, new blood vessels, and the epidermal layer becomes more regular (Fig. 7), until the grafted tissues become well ordered (Fig. 8), approaching in appearance the surrounding skin. The previous illustrations are from litter mate puppy grafts. A topographic section of a rat litter mate graft at six weeks is shown in Figure 9. Although the changes illustrated may be considered typical, there are many variations in the quality and quantity of the tissue response, its sequence and duration. Some of these may be explained as due to technical variations. Any experimental procedure which depends upon technical facility and fallible human interpretation seems likely to be subject

FIG. 6. Litter mate (puppy) graft at nine days. The cellular infiltration is being replaced by actively growing fibroblasts. The epidermoid hyperplasia is so marked as to suggest neoplasia.

to some variability. As is well known by surgeons, autogenous grafts are not without variations in qualitative and quantitative perfection, more often due to technical irregularities than anything inherent in the tissues of the recipient.

COMMENT

Evidence has been presented which suggests that among three species of adult experimental animals cutaneous homografts are generally unsuccessful, while similar grafts between young litter mate animals of these species are commonly successful. At some time after the first two or three months of life the latter lose their tolerance to grafts from other animals even when closely related. It is known that most animals at birth and for some weeks thereafter produce feeble antibodies, whereas later they can be actively immunized. The parallel in age of animals in relation to development of immune bodies and intolerance of litter mate skin gives cause for speculation.

Medawar[8–12] and associates have carried out an elaborate series of experiments on rabbits, the results of which suggest that natural or acquired immunity are important factors in the survival of homografts. They have demonstrated, among other pertinent findings, the dosage factor in graft survival and that graft survival is altered by active immunization of the animal against donor tissue. They have produced suggestive evidence that only vascularized tissues are subject to immune reactions. Dempster and Lennox[3] altered the survival time of grafts by the use of multiple donors. It has been assumed that lymphocytes play an important part in the reaction of host tissue to the transplant. Loeb[5] presented evidence for chemotropic migration of lymphocytes from the host to the transplant and found that efforts to knock out the hematopietic system were unproductive. Stark[15] and Rabinovici[14] were unable to influence the survival of grafts by depressing the reticuloendothelial system. Depressed tissue response in animals and humans treated with adrenotropic hormones were demonstrated by Baxter[1] and others. Billingham, Krohn and Medawar[2] repeated some of their experimental grafts in rabbits treated with cortisone and found that necrosis of the cutaneous grafts was delayed by a few days, approximately the time of retardation of the tissue response. Morgan[13] showed longer survival of homografts in cortisone-treated recipient animals, but noted a high incidence of infections among the animals so treated. Weisman et al.,[16] Ellison et al.[4] and Baxter[1] found no longer survival of homografts in humans or experimental animals treated with the hormones.

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FIG. 7. Litter mate (puppy) graft at sixteen days. The cellular infiltration has been replaced by orderly fibroplasia and collagen formation. The epidermal layer has become more regular.

FIG. 8. Litter mate (puppy) graft at twenty-six days. The normal skin is at the top, the skin graft pocket below. The arrangement of the tissues in the graft has become more regular and approaches the normal. There are fewer hair follicles in the graft and the fibrous tissue of the corium is somewhat more dense than that of the adjacent normal skin. The subcutaneous muscle of the animal lies between the skin surface and the graft. Its fibers have been sectioned longitudinally in the photomicrograph.

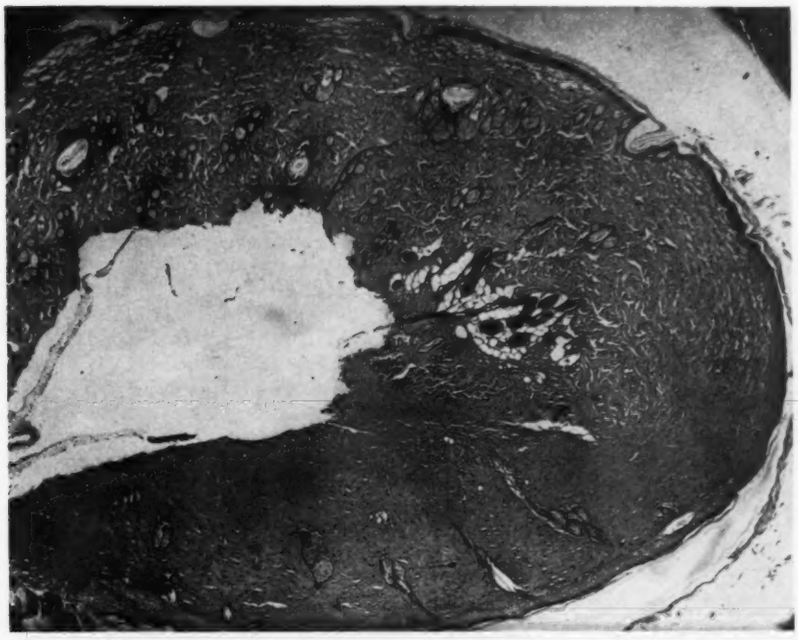

FIG. 9. Litter mate (rat) graft at forty-two days. The normal skin is in the top half of the photomicrograph; one side of the skin grafted pocket is below. The central clear area is an artefact produced by fixation. Cross sections of the subcutaneous muscle fibers are seen at the line of junction between the normal skin and the graft.

It may be argued that successful cross grafting of litter mate animals may be the result of accidental inbreeding. Loeb and associates[5–7] have shown, however, that although close relationship of donor and recipient animals may influence to some degree the survival of homotransplants of various tissues, the pattern is little altered by intensive inbreeding. According to Loeb[5] organisms exhibit varying degrees of autonomy both as to the entire animal and as to specific parts, expressing varying degrees of hostility or defense reactions to foreign tissues. These vary with the genetic constitution as well as phylogenetic and ontogenic stages of development. The reaction of the individual to foreign tissue may be acquired or hereditary, and it may possibly be modified. The reaction to different tissues may not be identical; for example, the reaction to cartilage transplants is usually less than to skin. In general, animals at birth and during early life show little reaction to certain organisms but, on the other hand, some show more at birth than later. The method of differentiation is unknown, but it may be due in part to chemical differentiation and in part to latent exposure to unknown substances. Evolution has led to gradual differentiation and specialization of tissues and organs. Efforts to change these organismal differentials have been only partly successful.

The observations of the author concerning litter mate grafts have only negative value. Their only clinical application is found in the doubt they cast upon our ability to use cutaneous homografts as anything other than temporary surface dressings, in the light of our present understanding.

CONCLUSIONS

1. In the state of confusion that exists in the literature on cutaneous homografts, it seems desirable that experimental methods be used which may be interpreted clearly. A simple method of performing experimental grafts is described. The resulting pocket grafts are readily accessible for objective evaluation.

2. It has been demonstrated that in three species of animals, grafts between young litter mates are commonly successful, although later in life similar grafts between the same animals fail.

3. It is suggested that the latter phenomenon is the result of gradual development of hostility to homogenous tissue as the organismal differentiation of the individual proceeds with

growth and aging. The development of tissue immunity may be a factor, but probably is not the only factor.

4. The histologic changes shown by compatible and incompatible cutaneous grafts are illustrated.

Acknowledgment: The generous assistance of Dr. V. L. Tichy during the early part of this work is acknowledged.

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MASSIVE AVULSION OF SKIN

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IN this mechanized era injuries causing massive avulsion of skin are not uncommon. On the other hand, such cases are rare enough so that one surgical service sees relatively few cases in comparison to their total admissions. This inexperience may be one explanation for the reluctance with which the principles of management described by Farmer[1] in 1939 have been accepted. There is a natural timidity which must be overcome in detaching avulsed flaps of skin from the small blood supply which remains. It has been our experience that a few avulsed skin flaps which are left attached and sutured back into place will survive. A greater number, however, will develop some degree of or complete necrosis. This is particularly true where the avulsion is massive. Objections to replacing contaminated skin as a graft may be discounted if the graft is prepared properly and antibiotics are used. The manner of preparation of the graft does not violate the surgical principle of gentle handling of tissue. No ill effects result from preparing the graft by scraping with a sharp knife. Even in the most severe injury rarely will the avulsed skin be so badly traumatized that it cannot be employed as a graft. Following are two case histories of patients with massive avulsion of skin, each treated in a different manner.

CASE REPORTS

CASE 1. A fifty-one year old white woman was admitted to the Third (N.Y.U.) Surgical Division of Bellevue Hospital on July 5, 1949, after having been struck by a truck, injuring her right arm. Figure 1 shows the right arm when the patient was placed on the operating table. It may be seen that the patient had an open dislocation of the elbow. The ulna was fractured in its mid-portion but the fragments were in good position. There was also an open dislocation of the first and second metacarpophalangeal joints. At the elbow the attachments of the tendons of the common extensors and flexors of the forearm were avulsed, the former carrying a small fragment of bone with it. The vascular supply to the arm and the peripheral nerves were intact. The skin with the subcutaneous tissues was avulsed from the underlying fascia from the shoulder to the heads of the metacarpals. There were numerous lacerations of the detached sleeve of skin but it was attached completely at the shoulder and distally in the palm of the hand.

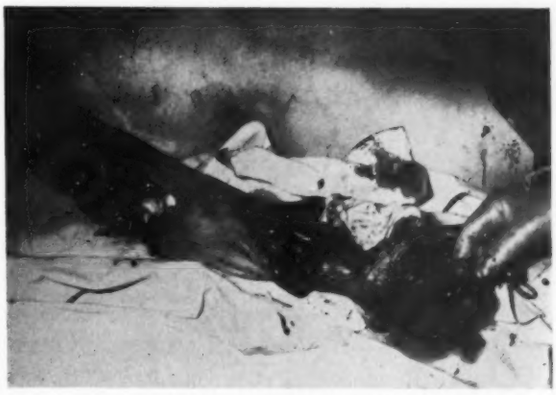

FIG. 1. Case 1. Shows extensive avulsion of skin and soft tissues of right arm with compound dislocation of the elbow joint and fracture of the olecranon.

As soon as the patient's general condition responded to shock therapy, she was given a general anesthetic and the avulsed skin was severed from the shoulder and from its attachment in the palm. The entire sleeve was then split and removed. One team of surgeons proceeded to remove the fat and subcutaneous tissue from the detached skin by scraping with a sharp knife and cutting with scissors. The skin was irrigated with saline and further bathed with a solution of penicillin containing 200 units per cc. While this was being accomplished, the traumatized tissues of the arm were carefully débrided by another team. The dislocations were reduced and the muscle attachments about the elbow fixed in place with fine wire sutures. An effort was made to reconstruct the capsule of the joint. A large amount of tissue from the bellies of the common extensor group of muscles of the forearm was devitalized and had to be excised. All superficial fatty tissue was removed from the arm. On completion of the débridement the skin which had been prepared was replaced as a full-thickness graft covering the area from just above the insertion of the deltoid to the dorsum of the hand at the heads of the metacarpals. The arm was dressed with thin strips of vaseline gauze over which sheet wadding was applied with gentle, even pressure. The arm was then immobilized in a plaster

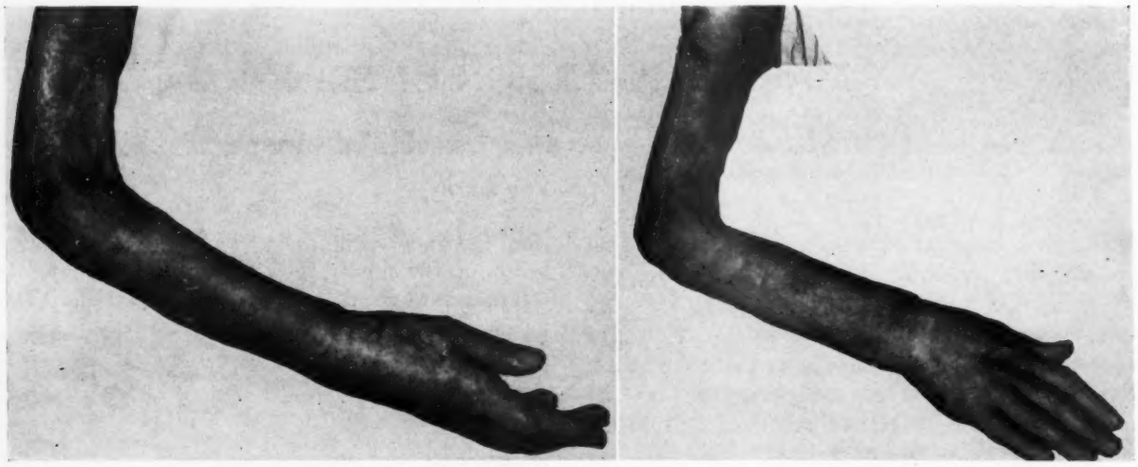

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FIG. 2. Case 1. Twenty-six days after injury showing healing of replaced graft.
FIG. 3. Another view of same arm.

FIGS. 4 to 7. Shows function of arm and degree of healing two and a half years after injury.

cast from the shoulder to the heads of the metacarpals. The cast was removed on the twenty-sixth postoperative day and the skin was found to be viable except for one small area over the lateral condyle which failed to heal. Figures 2, 3 and 4 show the patient's condition at that time. She did very well. She was further immobilized until the fracture of the ulna healed and then an intensive rehabilitation program was begun. She was discharged from the hospital on December 8, 1949, five months after injury.

Figures 5 to 8 show the patient at present. She has a good functional recovery of both the hand and the elbow; there is limitation of extension at the elbow to 120 degrees and weakness in extension of her fingers. She has a useful hand and arm.

CASE II. This patient, treated on the same service, was a twenty year old woman who was in a bus accident on January 16, 1950. At this time, besides numerous other injuries, she received a stocking avulsion of the skin and subcutaneous tissue of the right lower leg. The skin was avulsed from just below the knee and rolled down intact to the mid-portion of the distal one-third of the

FIG. 8. Shows degree of healing two and a half years after surgery.

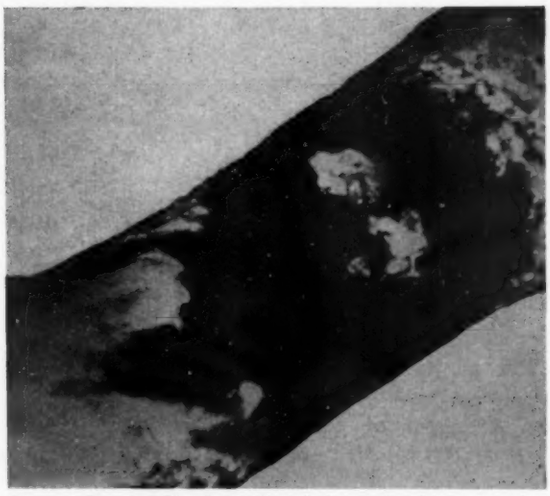


FIG. 9. Case 11. Six days after injury showing extensive necrosis of skin of lower leg which had been replaced by simple suture.

lower leg. There was also an open fracture of the mid-portion of the tibia and fibula. The patient was admitted in the early hours of the morning. The leg was carefully treated, all devitalized tissue removed, the fracture reduced, the tissues carefully irrigated and the skin rolled back and sutured, having been left attached distally.

It is unfortunate that no photograph of the leg was taken when the patient was admitted; however, Figure 9 shows the skin of the avulsed area

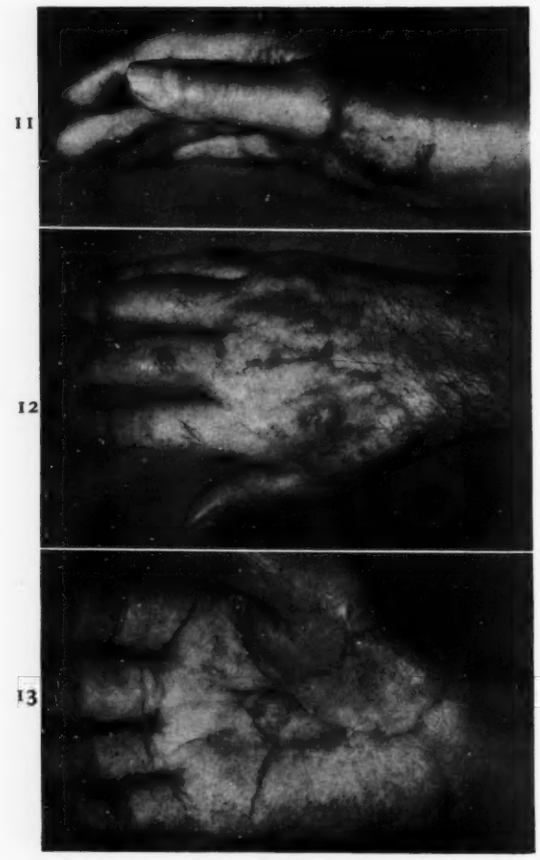
FIG. 10. Case 11. Two years after injury showing healing after repeated split- and full-thickness grafts.

six days after injury. Practically the entire flap is necrotic and will have to be removed. The resurfacing of this leg has taken numerous initial split grafting operations and finally a cross leg flap, and almost two years in time before the bony structures have been returned to a favorable environment. The fracture has not united and further major surgery will be required before healing is complete. Figure 10 shows the leg at present just prior to bone grafting.

We believe that the marked contrast these two cases present serves to emphasize the validity of the principle of the management of avulsed skin by complete detachment, scraping and replacement as a full-thickness graft. Comparison of the time of healing is measured in years and certainly the ultimate functional differences of the affected members will be great.

When internes and residents are being trained who soon may be called upon to treat the terrible injuries of battle, certain surgical principles must be maintained. Although these are pliable and require intelligent judgment in application, they must to a certain degree be fixed. With these basic principles the management of avulsed flaps of skin by detachment and reapplication as a graft should be included.

In avulsions of lesser degree the principle is



FIGS. 11 to 13. These illustrate complete healing in a patient with avulsed flap of skin of right hand replaced by the Farmer method. Pictures taken six weeks after injury.

FIG. 14. Shows healed flap of the right arm in another case fourteen days after avulsion. Flap replaced by the Farmer method.

FIG. 15. Shows well healed chest wall after removal of both breasts for fungating tumor. Denuded area covered with scraped full-thickness graft.

equally true. Figures 11 to 13 show the end result of a flap avulsion of a hand caught in the roller of a baking machine. The flap was lifted from the palm of the hand, extended around over the first metacarpal to the dorsum of the hand and was fixed there by a pedicle. There was associated open fracture of the first metacarpal. The pedicle attachment was severed, and the skin treated and replaced as a graft with quick and successful healing. Rehabilitation of the hand was greatly facilitated.

Figure 14 shows another patient who had a flap avulsion of the arm when it was caught in a roller in a lace mill. The skin was attached by a wide pedicle but this was severed and the skin replaced as a graft after preparation. There was a 100 per cent take.

The application of this principle extends into other fields of surgery in which thin skin flaps of necessity have to be raised. In radical removal of the breast where there is very meticulous development of the skin flaps so that a maximum of fat and subcutaneous tissue is removed, almost invariably there is some degree of necrosis of the wound edge. We would advocate complete removal of these flaps, careful scraping and replacing as a graft.

In the following case something similar was done: This woman had advanced cancer between both breasts. She had very pendulous breasts and to remove the fungating mass and cover the area with skin would have required a rather large flap. The flap was developed from the lateral side of the right breast, detached, scraped and replaced as a full-thickness graft, with success. (Fig. 15.)

In summary, we have presented several examples of avulsed skin treated by the method advocated by Dr. Farmer of Toronto. Two of

these cases were of massive avulsion and by contrast serve to emphasize the basic principles in the treatment of avulsed skin.

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MENISCECTOMY FOR INTERNAL DERANGEMENT OF TEMPOROMANDIBULAR JOINT*

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THE temporomandibular joint is subject to the same pathologic lesions as other joints in the body such as tumors, arthritis and trauma. The most common lesion, other than fracture dislocation of the neck of the condyle involving the joint, is internal derangement of the structures contained within the capsule.

Anatomically, this joint is very complex because of its various movements. These include a forward or sliding movement, a hinge-like motion as well as lateral excursions. A dense, fibrous connective tissue capsule extends completely around the joint and fixes the condyle in the glenoid fossa with its attachments from the zygoma and temporal bone down to the neck of the condyle. (Figs. 1 and 2.) This structure is further supported by the stylomandibular ligament on its posterior surface, the sphenomandibular ligament on its medial surface and laterally by the very short, dense temporomandibular ligament.

This joint differs further from other joints by the fact that it is divided into two compartments by a dense fibro-elastic cartilaginous meniscus. (Fig. 3.)

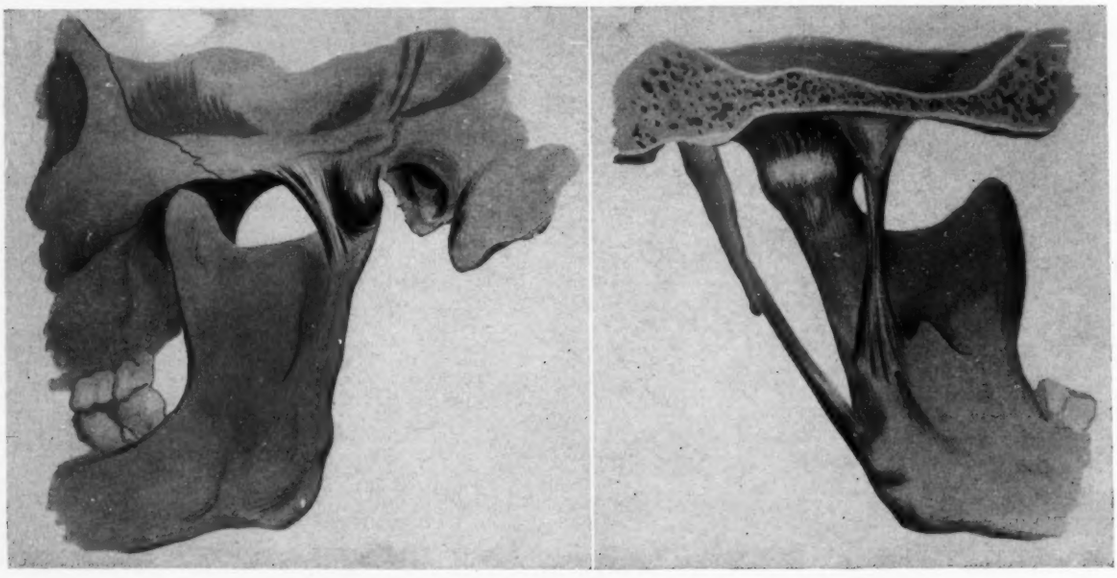

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FIG. 1. Temporomandibular ligament and capsule. From Gray's Anatomy, 28th ed. New York, 1944. Longmans.
FIG. 2. Temporomandibular joint capsule, sphenomandibular and stylomandibular ligament. From Gray's Anatomy, 28th ed. New York, 1944. Longmans.

Each compartment is lined with a synovial membrane.

Various types of trauma are transmitted to this joint either directly over the joint or indirectly along the ascending ramus from a blow on the symphysis of the mandible. The trauma may be of a mild, chronic nature as prolonged mastication of very hard foods, over extension of the joint by yawning or by some operative procedure, such as removal of a difficult impacted third molar tooth or a tonsillectomy. Malocclusion of the teeth also causes abnormally distributed forces to the joint contents and capsule. These etiologic

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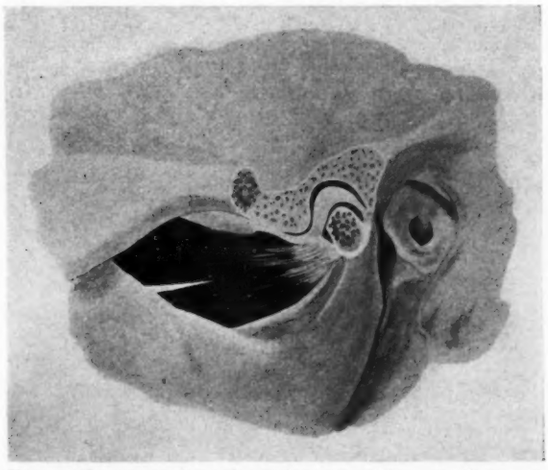

FIG. 3. Cross section of meniscus and its attachments. From Sabotta and McMurrich. Atlas of Human Anatomy. New York, 1936. G. E. Stechert and Co.

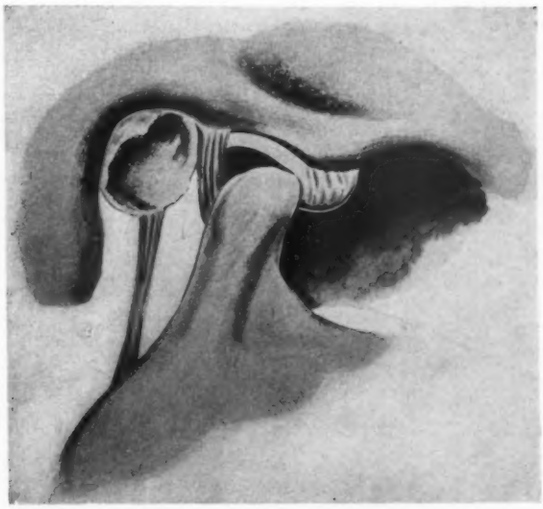

FIG. 4. Meniscus interposed between condyle and articular eminence.

factors may result in dysfunction of this joint by the long application of chronic trauma and are most commonly seen as compared to the abrupt, forceful trauma causing acute rupture of the disc and fractured condyle.

The first complaint that the patient may have is a crepitus or a grating sound which is heard by the patient when the jaw is functioning. This disturbing symptom is due to a loss of normal joint fluid and a mild disturbance of the mechanics of the joint. This can be heard on auscultation and varies in degree with the amount of pathologic disorder present. As this process progresses a mild clicking sound will be elicited when the mouth is opening and closing in wide extension. This clicking sound will become more pronounced as time goes on if the etiologic factors are not corrected. The mechanism of production of this sound can be easily demonstrated during the operation. (Fig. 4.) The patient, under a local anesthetic, is asked to open his mouth and the excursion of the condyle can be observed. It is found that as the condyle moves forward it pushes the abnormal thickened meniscus ahead of the anterior surface of the condyle causing an interposition of this fibrous mass between it and the articular eminence. On further opening the head of the condyle is lifted over the entrapped mass resulting in a clicking sound as it progresses over the articular eminence.

If the pathologic process has progressed further, other symptoms are observed, such as pain, which when present in the acute stages is sharp and continuous and may be referred to the ear or down into the cervical region. In the more chronic cases the pain may be interpreted by the patient as a burning sensation in the tongue or lateral pharyngeal wall. Usually it is not elicited unless the mandible is functioning as in prolonged mastication of solid food or if the area is palpated with deep pressure over the joint or along the ascending ramus of the mandible.

Limitation of motion of the mandible is an important clinical sign. The extent of the excursion of the mandible depends upon the amount of dysfunction present in the joint. As the mouth opens there is a deviation of the symphysis of the mandible toward the affected side. This is due to the fixation of the condyle on that side caused by trismus and a normal excursion on the unaffected side, which is not inhibited in its motion; therefore, it travels a greater distance. The jaw may be impossible to open at all because of muscle spasm and inflammation in the very acute cases. The patient will often observe in the more chronic cases that it is impossible for him to open his mouth in the morning but as the day progresses the jaw returns to its normal excursion. However, he is never able to open his mouth the normal distance, which is approximately 4 cm.

Locking of the joint is not a common symptom; but when it does exist, it indicates definite pathologic disorder in the meniscus. The head of the condyle is not able to return to the glenoid fossa due to the interposition

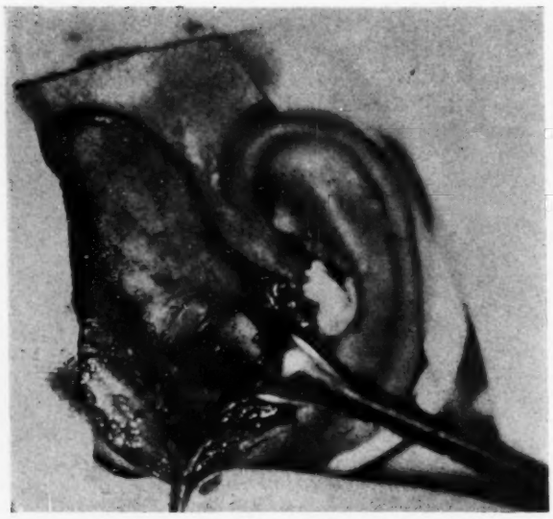

FIG. 5. Temporomandibular joint exposed through curved incision.

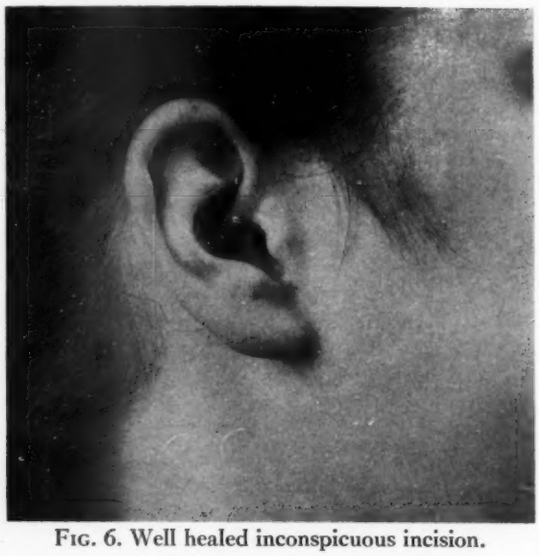

FIG. 6. Well healed inconspicuous incision.

of the meniscus between it and the articular eminence. Mild locking may exist in which the patient opens his mouth and then is not able to open it further nor can he close it for a few minutes after which it eventually goes back to its normal position. A more severe type of locking may be present in which the patient opens his mouth and it is impossible for him to return it to its normal position by any type of manipulation except that used under an anesthetic. This type of locking indicates severe damage to the meniscus and capsule and may lock in either the open or closed position. This requires early operation as delay will cause more frequent locking and discomfort to the patient.

Treatment of this lesion depends upon the severity and chronicity of the symptoms.

The more acute cases should be treated with sedation, heat and putting the joint at rest for a period of time. If malocclusion is determined as the etiology, this should be corrected and the jaws immobilized with interdental fixation for one month. If after this time crepitus and pain persists, a meniscectomy should be done. The indications for operation are pain, which has been present for a long period of time, locking, dislocation, limitation of motion and inability to chew solid foods.

X-rays of the joint are not diagnostic. In the open position they do show the head of the mandibular condyle, not traversing its normal distance because of the interposition of the meniscus. Pneumoarthrograms have been attempted, but the technic is not satisfactory to demonstrate pathologic disorder.

The operation can be done if the patient is heavily sedated and using procaine as an anesthetic. The operative field is draped in such a manner so that the muscles of the seventh cranial nerve are exposed. Great care must be exercised to prevent damage to this nerve. The frontal branch of the facial nerve is the most frequently traumatized because of a badly placed incision or due to the pressure of the retractor. If the latter is the cause of the palsy, the function will return in several weeks' time.

The incision, which begins in the hairline, is a curved one and extends posteriorly and downward inside of the tragus of the ear as far as the lobule. (Fig. 5.)

The superficial fascia is dissected back as a separate layer and with the skin and subcutaneous tissue is held in place with a suture. The zygomatic process is identified and the joint capsule is then opened and fluid of various amounts is usually present.

The meniscus can be exposed in its entirety by having the patient open his mouth, which will also demonstrate in many cases the interposition of the cartilage. It may be found to be thickened, roughened, completely eroded and pigmented from old hemorrhage into the joint. However, many cases show no evidence of gross or microscopic pathologic disorder but are completely relieved of their symptoms after removal of the disc. Great care must be taken to make certain that the entire disc

is removed so that the condyle will function normally. The medial anterior portion of the disc is obstructed from view by the head of the condyle and therefore is very inaccessible. However, with the patient moving his jaw in all directions, this portion can be removed. The wound is then closed in layers and a pressure dressing applied. (Fig. 6.)

Postoperatively it will be found that the teeth on the operative side will occlude before those on the normal side, that is, there will be an open bite equal to the thickness of the meniscus that has been removed. The occlusion returns to normal within a week. The patient is allowed to eat a diet that can be tolerated within two days.

Fifteen cases have been treated in this manner with complete relief of all symptoms and a return of normal function of the mandible in all of its excursive movements.

The following is a typical history of a patient who has had a meniscectomy:

CASE REPORT

L. B., age twenty-three, complained of pain in her right jaw which had been present for one year. At that time she awakened one morning and could not open her mouth. The pain that she had was dull and aching and as the day progressed she could open her mouth to a greater extent. This pain did not radiate. She did notice, however, that the pain became more severe with excessive motion of her jaw. She gave no history of clicking of the joint and the history was negative of other joint disturbances. She was referred to her dentist who constructed bite blocks which she wore for six months without relief of symptoms. Examination revealed a limitation of motion on opening of the jaw with deviation of the symphysis to the right and a partial fixation of the condyle. Crepitus could be heard on auscultation and pain was elicited by deep pressure over the joint and intraoral palpation of the ascending ramus of the mandible.

X-rays of the joint revealed limitation of motion of the right condyle; otherwise no abnormality was present. A diagnosis of internal derangement of the right temporomandibular joint was made and a meniscectomy was done under procaine anesthetic. Three weeks following the operation she had complete relief of pain with normal function of the mandible and has been free of all symptoms for a period of four years.

SUMMARY

Meniscectomy has a definite place in the treatment of dysfunction of the temporomandibular joint. This has been shown by the complete relief of chronic symptoms and return of normal function of the mandible in fifteen cases. The diagnosis is based entirely on signs and symptoms and operation is contraindicated in the acute cases with exception of acute dislocation and rupture of the meniscus.

DISCUSSION OF PAPERS BY DRS. GREELEY, SANDERS, GLOVER, MULHOLLAND, SIRIS AND MAHONEY, AND KIEHN

JOHN L. ATLEE, JR. (Lancaster, Pa.): I was most happy to hear Dr. Sanders in his beautiful presentation of the reconstruction of the thumb. I well remember the good work he did in Lancaster prior to 1942. As far as the radiation injuries are concerned, I can speak rather feelingly on the subject. Many years ago I was given competent x-ray therapy and I bear no resentment, but since that time two low-grade lesions have occurred and I think it is a problem that every physician has to face. There may well be certain differences in the vascular structures among individuals that account for such occurrences.

In the reconstruction of a thumb, there are a number of alternatives that must be decided on the individual case, namely, phalangitis, the rotary angular osteotomy, the possible use of tube grafts, digital transplants and the convenience of the "physiologic" thumb. My own experience is extremely limited. We have used phalangization in the few injuries we have seen, and in only one case was any type of tube or other graft used, and that case did not result nearly as happily as Dr. Sanders' cases.

PAUL W. VESTAL (New Haven, Conn.): I think Dr. Sanders has obtained some unusually fine results, starting with very little to begin with in many cases.

A case of reconstruction of the thumb was made possible by the transplantation, by tubular graft, of a stiff and useless ring finger on the same hand. This did not present so great a problem in reconstruction as some of Dr. Sanders' cases. The hand was caught between rolls of a cardboard press with a clearance of only ⅝ of an inch. That hand has been widened and the mass up at the top represents the extrusion of practically all the intrinsic muscles of the hand, the muscle bellies. The lacerations were extensive on either side of the hand. In other words, the only thing he had left was the extensor tendons of the fingers and a pretty badly mangled thumb.

We reconstructed the hand as well as possible and got the bone fragments back in shape. We tried to save as much of the thumb as possible, but it soon became gangrenous and had to be amputated at the first joint.

About that time, in our routine x-ray survey of the chest we discovered he had acute pulmonary tuberculosis. He was then isolated and it was some six months or more later before further surgery was attempted.

The first metacarpal and the remaining proximal phalanx is firmly adherent to the head of the second metacarpal. No muscle substance remained in the entire hand, only skin, tendons and healing fractures. The ring finger, due to crushed joints, was stiff and useless. The sacrifice and subsequent use of this finger in reconstructing the thumb and the web space between the first and second metacarpals is the principal reason for showing this case. The finger was useless but could serve in rebuilding the thumb and also the hand as a whole.

The bones of the proximal and middle phalanx, along with the fourth metacarpal, were removed. The blood and nerve supply was carefully preserved and the entire terminal phalanx transplanted by the tubular graft, composed of the remaining skin and soft parts, to the amputated stump of the thumb. This required almost a rotation of 180 degrees to bring the nail and palmar surface into proper position.

The proximal portion of the tubular graft was used to reconstruct the web space. You see a smaller than normal tip of the thumb, but he has a complete nail and better use of the hand. He has grasping power and fairly good use of the hand. He is a colored man with a college education but found he could make more money in industry than by using his college education. You would think, having a hand of this kind, that he would go back to his higher education and use his head instead of his hands, but no he is back in industry again.

He came in the other day with a cigar and a photograph of his newborn son, just to demonstrate that his tuberculosis was arrested. He had some disability of his hand but the rest of him was all right.

Burton C. Kilbourne (Chicago, Ill.): Not only has Dr. Sanders well described the reconstruction of the thumb, but he also has illustrated so well all of the principles of the treatment of hand injuries in which we believe. Primarily, his treatment included adequate débridement, still saving everything possible for future use; then primary closure with a combination of local flaps and grafts, followed with adequate splinting which helped restore the position of the fractured fourth and fifth metacarpals. Such treatment allows an early application of the reconstruction plan.

The length of the thumb which is necessary for good opposition varies directly with the condition of the other fingers. Dr. Sanders had a doubly difficult situation with the loss of the index and middle fingers and the lengthening procedure for the thumb was very necessary and well chosen. The fact that some radial rotation of the fourth and fifth metacarpals distal to the fractures occurred during healing may have been fortuitous or planned. We have made use of this principle as a deliberate rotational osteotomy of remaining fourth or fifth metacarpals in order to improve opposition of these fingers to a thumb stump, and it has been a helpful procedure.

Alfred W. Farmer (Toronto, Can.): I am here primarily to discuss Dr. Mahoney's article. I can only say that he gave us a beautiful demonstration of the use of the procedure of cutting avulsed flaps and replacing them. The case he showed was an extreme one, with a beautiful end result. We have had cases similar to that in both limbs, associated with fractures, and we have also had cases of large avulsions of the trunk in automobile accidents. These injuries are usually due to some rolling type of injury and we get a very large number of these in children due to wringer injuries.

I suspect that everybody gets the same number but they probably do not recognize them quite as often. We have seen within the last three weeks a case of avulsion of both lower limbs from Peterboro. We have also had a case of avulsion of all the skin of a forearm from Bradford, and we have had one further case in our own hospital, a wringer injury to a child. They do not occur quite that often but they occur many, many times a year so I think that one should be on the watch for this type of injury.

If you are going to use it, do not be timid about it. Cut the flap off, take the fat off it and put it back on again. The removing of the fat is a slow job. If it is a very large avulsion, it can be put on a Padgett dermatome without glue, with somebody holding it. This is a rapid method of removing the fat. Actually, one can cut into the dermis and make a split graft of it. Normally we would leave it as a very thick partial thickness graft or a full thickness graft.

Concerning Dr. Sanders' paper, I do not like using pedicle grafts from the abdomen as the tip of a thumb. I have had the dubious pleasure of being required to remove a number of them, usually with trophic ulceration; and if there is any other way of handling the situation, I think it should be used. His was a beautiful case and apparently worked out quite well. That just has not been our luck, let us say.

I noticed in his original picture he had a metacarpal bone of the middle finger and he had two-thirds of the first phalanx of the middle finger, but I did not notice in the first picture whether it was possible to use those for a thumb or not. We have used the middle finger in transpositions for thumb as well as the index finger.

Concerning the man's ability to use a transposed

finger as a thumb, it is possible to transfer the long tendons into long tendons of thumb which is, I think, of some help.

ROBERT H. KENNEDY (New York, N. Y.): I cannot help rising to say a word about Dr. Mahoney's case. I was asked by an insurance company in the early days of this case to see that patient. I was told by the insurance company that they had understood this was a case that needed amputation. Somebody was crazy enough to try to save it and hadn't done an amputation, and they wished I would see it. I reported to them that the only possible method had been used in which the patient might have obtained a useful arm following this.

I do not know why it is so difficult to get this method more widely adopted; it must be over ten years now that Dr. Farmer has been preaching this method. I think it is one of the hardest methods there is to get members of an attending staff and members of a resident staff to use. They seem to think it is a tremendously radical procedure to take off skin that has perfectly good margins hanging on, and that does not have much edema at the time, and to cut that away and reapply it on a fascial bed or a muscular bed as a full thickness graft. I think it should not be limited to the large areas by any means. There are many small areas in which we will save a tremendous amount of time to the patient and give a much better result if they are done when you first see them. Personally, I consider in any avulsion of skin that the radical procedure is to clean that up and sew it back, and the conservative procedure is to do a full thickness graft of the skin itself.

BYRON E. BOYER (Cincinnati, O.): I was particularly interested in Dr. Sanders' presentation because I was recently faced with that problem a few months ago. The case was of a young man twenty-six years old. While operating a power saw at an angle, the saw slipped down and produced this injury. Within two days' time a direct pedicle graft was put on from the abdomen and taken down at the end of four weeks. At a later stage a peg of cancellus bone, autogenous, of course, was inserted. After hearing Dr. Sanders' presentation, I probably could have put in the cancellus bone at the time the pedicle was applied. The patient has worked around my house and can handle a rake, hoe, mower and a spade. He has no movement, of course, but he has apposition.

ELDEN C. WECKESSER (Cleveland, O.): I would like to say just a brief word regarding the use of pedicle flaps in reconstructions of the thumb. My experience has not been tremendous but I have used it on several occasions and have been quite gratified, much as Dr. Sanders has been.

I wonder if the one main reason for trophic ulceration at the end of the pedicle flap is not the division of the tube in a guillotine manner so that a scar occurs right at the end. That has been my feeling at any rate, and I have amputated distal to the proposed length of the thumb and then made the excess end of the pedicle flap into a longer flap which I have carried back proximally, so that the end result was much as Dr. Sanders showed. It is my opinion that the difficulties with trophic ulceration come from leaving the scar right at the end.

I have had very gratifying success with one case, in particular, and another two I think are going to be just as good.

We have used cancellus bone. I have put it in later and still have not had trouble with the ulceration.

H. MINOR NICHOLS (Portland, Ore.): I would like to show three cases on avulsion of the skin and soft parts of the upper extremity. I have approached this problem in a little different way from Dr. Farmer's method and for reasons that I will describe.

This is a case of a woman who caught her arm in a haybaler. (Slide 1.) The sublimis muscles, the median and ulnar nerves and the profundus tendons except those to the thumb and index finger were avulsed and were attached only at the wrist.

At the primary repair the useless sublimis muscles and tendons were excised and the avulsed profundus tendons transferred to the two remaining deep flexor muscles. The nerve ends were tacked together with heavy silk. The skin flaps were replaced. As expected, a slough of the skin occurred and a massive abdominal flap was applied as soon as this happened.

This flap facilitated the final operation of nerve repair carried out about two months later. The median and ulnar nerves were then dissected out to the axilla, preserving the branches to the few remaining useful muscles. The nerves were transplanted subcutaneously to the front of the elbow and by flexing the elbow and the wrist, 5 inches of hopelessly damaged nerve could be resected and neurorrhaphy done.

The end result in this case is quite satisfactory. (Slides 2 and 3.) The woman can pick up and grasp large or small objects and has some return of stereognosis.

This is a case of a woman who was injured when the door of a car she was riding in came open and she reached out to grab it as they went by a telephone pole. (Slide 4.) She had a wide open fracture of both bones of the mid-forearm with skin avulsed from the entire dorsum and some tendons torn away. At the initial stage, the bones were fixed internally. The tendons were tacked together with wires. The skin was replaced knowing that it would possibly slough. One reason I left this skin over

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SLIDE 1. Photograph of injured parts.
SLIDES 2 and 3. End results after operation.

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the fracture was because the pedicle was on both ends, and I thought it might be saved.

As soon as the slough occurred, it was replaced with split thickness grafts. The hand in this case regained almost complete return of function. There is good quality skin coverage on the forearm (Slide 5) and (Slide 6) part of it is normal skin and part skin-grafting skin.

This case was a man who caught his forearm in a planing mill, a fairly standard injury in the Northwest. (Slide 7.) The skin, extensor tendons and part of the ulna were ripped away and were either missing or lying in little pieces in the wound. There was an open fracture of the carpus and of two fingers. There was not enough skin present to close the wound. In this case a wide excision of the

wound was done, the fractured ulna was treated by internal fixation and an immediate abdominal flap was applied. This enabled the tendons to be repaired at an early date and the man was back working in about six months. (Slides 8 and 9.)

EDWARD A. KITLOWSKI (Baltimore, Md.): Concerning Dr. Greeley's presentation, I think it was a magnificent one. When one sees those things, one always wonders about this: Does the intensive radiation prolong the life of the individual sufficiently to justify that mutilation? If the answer is yes, then we have no complaints to make.

Concerning the use of irradiation for epitheliomas on the face, about twenty years ago Dr. John Staige Davis, in collecting data for a paper, looked into that matter and we found that by far about 80 per cent of all those injuries caused by irradiation were caused not by the general practitioner or those people but by the men who are classified and certified in those fields. So when you see those things, you cannot always say, "Well, the fellow does not know what he is doing."

In the case of these little lesions on the face, particularly those in the upper half, the basal cell type, a great many of those are tremendously resistant to irradiation. We in our section of the country have adopted this rule that if a dermatologist or the irradiation therapist gives them one treatment and there is not a marked improvement; or if after the second treatment there is not a decided improvement, then they no longer give them irradiation and send them for excision. We have found that to be extremely satisfactory in handling those types of things.

Concerning the reconstruction of the thumb, I think that Dr. Sanders was very wise in selecting cartilage instead of bone. Again the bone peg, when it does not have the stress and strain of the demands that nature puts on a bone, will always be absorbed sooner or later. The calcium will be taken out of it by nature if the stress and strain are not there so that you can expect, when you use bone pegs, that sooner or later you are going to lose the peg in your reconstruction.

Cartilage does not behave so and you can take a piece of cartilage and bury it in the abdominal wall, for instance (which we have done), and recover that cartilage twenty-five years later, and to all intents and purposes it has the same consistency, the same strength, the same appearance as the cartilage in the rib itself. Therefore, that cartilage will stay and remain useful.

As far as flaps are concerned from the abdomen, and the ulcerations, I think that the error there comes in making them too long, and the added length means that the regeneration of nerves is so much further prolonged that you get trophic disturbances in the ends of those things before they are able to take care of themselves. The regeneration in the flap, we have found, was about 9 mm. per month beginning about three months after the flap has been put down, and it comes from the distal end, so that it gradually comes up to the point. So, you can realize how long it will take the sensations to recover themselves completely in a flap of any length.

Concerning Dr. Glover's paper, I think that is a fascinating work. In conjunction with that, I might call your attention to experimentation which is being done in Bethesda. They take it as a standard rule that if you put a mouse through twenty generations of inbreeding, every mouse in that litter will be an identical mouse, so they have taken mice A and mice B and crossbred them for twenty generations, getting group C. On group C they can take skin from A or B and put it on C and it will take 100 per cent, but the process is not reversible. Therefore, it must be an anaphylactic something or other which we have, and Dr. Glover demonstrates that apparently it does develop a short time after birth. Along those lines, it is perfectly possible that maybe some day we will be able to find out just exactly what that factor is and overcome a tremendous obstacle.

Concerning Dr. Mahoney's grafting of the skin, there are some factors that I would like to call your attention to that may have an influence on the survival of those grafts. If you get a pinching accident where a wheel runs over, say, a calf and the skin and subcutaneous fat are pinched off, the odds are very, very much against you that that skin will survive after you have taken the fat off and put the skin back on.

In other cases in which it is just torn off, then the odds are tremendously in your favor that the graft will survive. Another thing which I think may play a part is this: one should never use scissors in taking the fat off of those pieces of skin. Scissors are a pinching instrument and pinching traumatizes the skin further, no matter how sharp your scissors are. Use a knife or, as Dr. Farmer suggested, a Padgett dermatome which is, again, a knife and shortens operating time.

In these wringer accidents, we have found almost 100 per cent failure in those skin grafts which we have taken and put down and where the skin has been so badly pinched by a wringer as it goes over those things. Probably Dr. Farmer's experience is a little happier than ours, but in those cases we put it back. We do it and put it back hoping that maybe something will happen. Occasionally it does, but invariably we have to plan for removal of that and replacement with a graft.

NORMAN L. HIGINBOTHAM (New York, N. Y.): I would like to add my fire to Dr. Greeley's effective barrage against the indiscriminate use of x-ray as applied to surgery. I think it was in 1948 that we published eleven cases of osteogenic

sarcoma which had developed seven to ten years following irradiation therapy given for various benign tumors. Since that time, we have collected five additional cases of osteogenic sarcoma that have developed in the irradiated area following heavy irradiation or even moderate irradiation in the treatment of certain tumors.

This bears out, then, that it is not only carcinoma but also sarcomas that may develop subsequent to irradiation therapy.

We have one man, a veterinary surgeon in New Jersey, in whom it was necessary to do bilateral amputation because he developed carcinomatous changes in irradiated areas following the treatment of plantar warts. The irradiation therapy in his case was not given by an expert radiologist. It was given by a technician who did not know the factors and did not know the hazards. However, it is something that we always have to bear in mind.

I hope that we as surgeons will soon learn that irradiation is a radical method of treatment. We believe that probably the dictum should be well observed that irradiation should be used or employed in the treatment of radical diseases such as cancer and should not be applied indiscriminately in the treatment of benign and inconsequential little lesions which very often can be very easily handled by the surgeon in the first instance and not relegated to the radiologist just because we are too lazy or do not know enough about them to treat them surgically.

I think very often we fall into the habit of doing inadequate surgery or incomplete surgery, with the thought that we can turn over the incompleted procedure to the radiologist to clean up for us. We have to treat conditions surgically ourselves if the method of treatment in the individual case is a surgical problem.

HARRY H. CAMPBELL (Toronto, Can.): Dr. Kiehn brought forward a very good point in his meniscectomies for internal derangements of the temporomandibular joint and this painful condition is a lot more common than a lot of us think. Until one sees a patient who has had these rather severe symptoms for some time and has had quite a lot of treatment by dental surgeons who try to build the bite, and so on—and they still have their symptoms—he cannot realize what a great relief it is to the patient to have the temporomandibular joint cartilage excised.

The condition occurs in quite a few people for the first time after removal of teeth, with the increased excursion of the mandibular head pinching the cartilage. These people respond very well, too, to removal of the cartilage.

I would not say that, when one sees erosion of the head of the mandible, it should be excised straight away. One has observed quite considerable erosion of the upper anterior lip of the head, has smoothed this out and has encouraged the patient postoperatively to chew on the side of the lesion. After a while, the process settles down without pain, and I think we should reserve excision of the head for a secondary procedure if this did not work.

The problem of stiffness in these joints after operation is a very minor one and, as Dr. Kiehn pointed out, they respond very rapidly to the excision of the irritating cartilage from the joint mechanism. I think he is to be congratulated on bringing this subject forward for our thought and consideration.

HAMILTON BAXTER (Montreal, Can.): I would like to take a few moments to congratulate Drs. Greeley and Glover on their papers with regard to irradiation necrosis and the attempts at homografting. The more we know about treatment of irradiation injuries and homografting of skin the better. Dr. Glover's paper recalls an experiment performed by Medawar in which homologous skin grafts from one rabbit were placed on a raw bed on cerebral cortex of another. The graft survived for some months. As soon as a similar skin graft from the same donor was placed on a raw subcutaneous bed, the graft in the brain degenerated and was lost.

DONALD M. GLOVER (Cleveland, O.): I would like to comment on one point of Dr. Greeley's excellent discussion which I think is particularly important to this group and that is the point of the effect of irradiation on epiphyseal growth. He mentioned it in connection with the maxilla and mandible. We have also seen damage similar to what he has described in long bones, affecting growth in one instance, with very serious damage to growth in the distal radial epiphysis. I believe that is an item not commonly recognized either by radiologists or by many orthopedic surgeons, namely, the potential dangers of the use of irradiation over growing epiphyses.

I would like also to comment on Dr. Sanders' excellent discussion on one point, and that is in regard to the nerve supply to the reconstructed digit. It is definitely an advantage to be able to use original nerve supply where it is possible. However, we have in two instances had an opportunity to observe the ingrowth of digital nerves in pedicle flaps about bone grafts which had been added to give length and in one case the thumb and in the other case the index finger where there was no question that the digital nerves did regenerate and provided very satisfactory sensation. Admittedly, however, epicritic sensation is never completely restored.

PAUL W. GREELEY (Chicago, Ill.): I was delighted to hear Dr. Glover present his paper and to emphasize the fact that we are still right back

where we have been all the time, and that is, that you cannot take skin from one person, transplant it to another (except in the case of an identical twin, of course), and hope to have it grow. Reports of this kind are frequently appearing in the newspapers, telling about the great success that was achieved; how the poor burned child was saved by the firemen and other relatives who donated their skin. There is never a follow-up news item. You never hear what happens. Those of us who have dealt with that problem know what is going to happen. We cannot transplant skin from one person to another and hope it is going to maintain its growing status longer than two to four weeks.

The other thing which I wish to bring out is a point regarding Dr. Sanders' paper which was alluded to but was not discussed adequately, and that is the question of the type of sensation which you get in a newly reconstructed thumb. In the type of thumbs which he showed, there is no chance ever of developing stereognosis in that thumb. We have in our fingertips, as you all know, Pacinian corpuscles which give us the sensation of stereognosis; and if you are transplanting abdominal skin which does not have the Pacinian corpuscles in it, you can never hope to develop sensation which will include stereognosis. You will include all the other sensations but that thumb will not develop stereognosis. The one advantage of using a finger for the reconstruction of the thumb is that you are transplanting a finger which still has its Pacinian corpuscles intact.

I am opposed to sacrificing and cutting down a perfectly normal index finger to bring it down to thumb length. Sometimes in the transplantation of that finger to make a thumb, certain things are lost. You might lose either a part or all of that index finger and this, of course, would be a catastrophe. If one has a partly mutilated index finger, I think it is an excellent procedure to utilize it. If you do not have that, I then believe that one should either select another finger or use the method which Dr. Sanders presented so well this morning.

I would like to ask Dr. Sanders if he knows of any satisfactory method by which one may transplant a new thumbnail and make it grow.

GEORGE B. SANDERS (closing): I would like to thank Drs. Kitlowski, Greeley and Weckesser for making more clear some of the principles to which I merely alluded, and perhaps badly, in presenting my paper.

Dr. Farmer, I have used abdominal tubes and flaps of varying sizes and shapes in quite a large series of reconstructions of thumbs and fingertips, and I have not thought that trophic ulceration occurred with any degree of frequency in my series. As a matter of fact, I can hardly remember any that did, provided one adhered to the principles expressed by Dr. Kitlowski and published by him, I believe, many years ago, on being conservative enough about the amount of replacement that you attempt to get with the flap or tube.

If you make them too long, the deprivation of sensation from the tip, and of circulation, is undoubtedly going to encourage a disposition to ulceration. If you control yourself and do not try to achieve what nature created originally and get your patient and yourself to accept the deficit, I think you will be very much happier.

As to Dr. Greeley's question about the thumbnail, of course, I know of no way to do that. In certain of my female patients we get them to wear an artificial nail for the sake of appearance only.

JESSE W. MAHONEY (closing): I would like to thank the discussers of my paper, and especially Dr. Nichols for the presentation of those three interesting cases. I want to commend the manner in which these terrible injuries were handled surgically, and the excellent results. I do believe that, particularly in the second case, he could have saved the patient a little time if the principles of removing the skin had been followed. Dr. Nichols brought out the point that it was attached by two flaps. As Dr. Farmer has pointed out, and as we have seen on two occasions in wringer injuries of the forearm in which there has been avulsion with no laceration of the skin still necrosis ensued. There was no question of extent of attachment of the skin, only of avulsion.

We instruct our interns who ride the ambulance that if they find a piece of avulsed skin at the site of an accident, to bring it in, because we like to use it. Dr. Kitlowski will probably frown on that, but we believe that at least an effort should be made to salvage the skin. If this should fail, we go ahead and do what is necessary.

USE OF ACTH AND CORTISONE IN SURGERY*

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IT would be most helpful if some interim evaluation of the potential clinical use of ACTH and cortisone, which have been used with increasing frequency during the past two years, were attempted at this time. The inhibitory effect of these hormones on the healing of wounds, proliferation of fibroblasts, budding of capillaries and formation of granulation tissue in laboratory animals has been shown by many investigators.[1–6] Some reports[7,8] have indicated that cortisone causes atrophic changes in the skin of the rat and rabbit. In the experience of most workers the various common laboratory animals have shown quite uniform experimental results, with the exception that the rat has been found to be more resistant to ACTH and cortisone than the rabbit.

WOUND HEALING

Early observers[9,10] reported the clinical observation of delay in healing of biopsy wounds in patients receiving parenteral therapy for various chronic diseases. We have reported the action of ACTH on contralateral, control and treated wounds[8] on the abdomen or thigh in four patients who volunteered while undergoing treatment for various conditions such as psoriasis, rheumatoid arthritis or atopic dermatitis and one otherwise normal patient requiring a pedicle transfer. With one exception 100 mg. of ACTH was given in four equally spaced and divided doses daily, beginning within twenty-four hours of creation of the second wound, for varying periods of time up to two weeks. The technic of creating the wounds has been described.[8] This is a controlled study of wound healing in man, using the same individual as an internal control.

It is known that there is a variation in the rate of healing not only in different individuals but also in the same individual in health and disease. Contralateral wounds in the same person, studied in sequence, help to reduce to a minimum the systemic factors such as age, general metabolic state, nutrition and hematologic or systemic disease. Certain phases of hormonal behavior require elaboration. The effective dose of ACTH differs widely because it may cause varying adrenal steroid output because of differences in functional capacity of the adrenal gland in different people. The general nutritional status of the patient at the time must be considered. In two patients healing in the treated wound was delayed (Figs. 1 and 2); in two others the rate of healing was equal (Figs. 3 and 4) and one patient with rheumatoid arthritis showed equivocal results. Excretion studies were carried out and did not reveal any correlation between the rate of healing and adrenal response. In those cases in which a delay of healing occurred, the pattern of healing of the wounds was unaltered.

HOMOLOGOUS SKIN GRAFTS

After ACTH and cortisone became available for experimental use it was shown that they were most effective in suppressing allergic or antigen-antibody responses of patients.

The most popular of the various theories which attempt to explain the failure of permanent survival of homologous skin grafts in man is the "active immunity theory." The homograft is thought to form antigens which evoke the production of antibodies by the host and the graft is eventually destroyed by the antigen-antibody response. Whitelaw[11] reported a case of severe burns in which it was claimed that homologous pinch grafts survived permanently under ACTH therapy. In two articles[12,13] we reported complete failure of permanent survival of four homografts of skin under ACTH therapy. Subsequently, another patient pretreated with 200 mg. of cortisone daily for seven days and postoperatively for twenty-four days

* From the Royal Victoria Hospital, Montreal, Quebec. This project was aided by a grant from the Southam Company of Canada. ACTH and cortisone was supplied by the National Research Council of Canada.

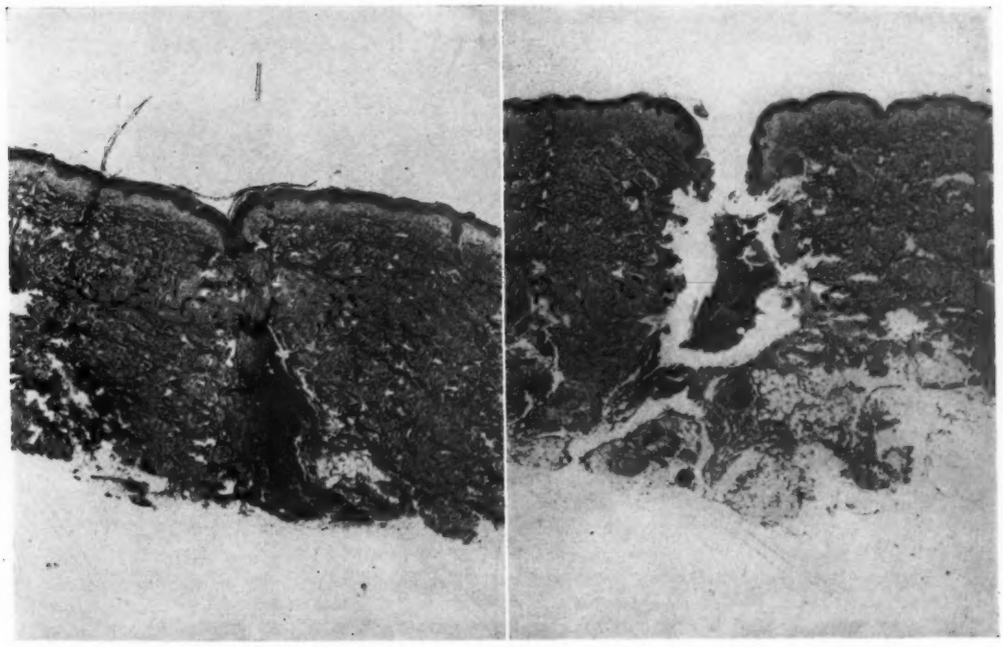

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FIG. 1. Control wound on the fourth postoperative day; there is firm epithelial union and some fibroblastic proliferation.

FIG. 2. Same patient, treated wound demonstrating the healing of a contralateral wound while receiving 100 mg. of ACTH daily. There is only slight epithelial proliferation; the wound edges are separated, and fibroblastic and capillary proliferation were not seen. A second biopsy on the seventh day showed epithelial union and in the depth of the wound an occasional fibroblast but no capillary proliferation.

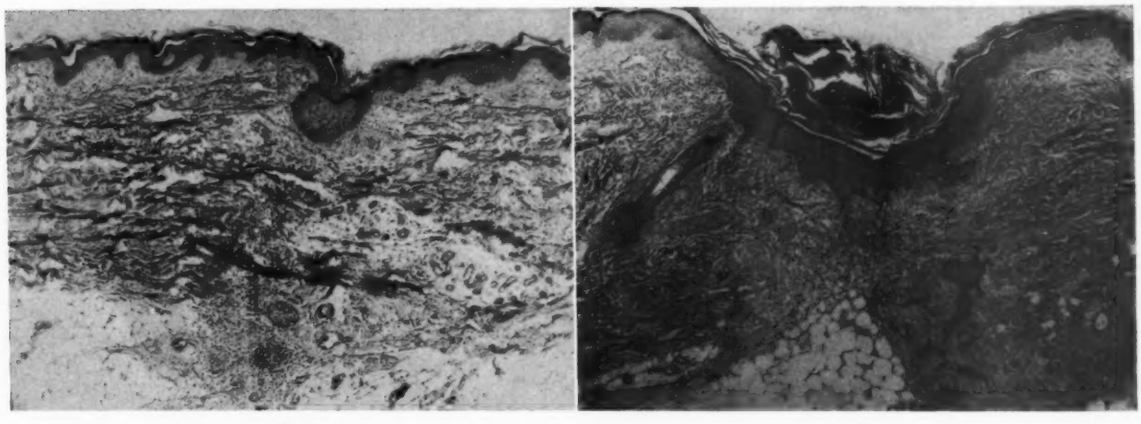

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FIG. 3. Biopsy of control wound seven days postoperatively; epithelial union is firm and there is vascular granulation tissue uniting the wound surfaces throughout their entire length.

FIG. 4. Biopsy of treated wound seven days postoperatively; although the wound is wider, there is epithelial union and granulation tissue formation equivalent to that of the control. The epithelium situated to the right of the fat tongue is proliferating from a hair follicle.

lost a homologous graft of skin in the usual time (Figs. 5, 6.) A considerable number of surgeons have obtained similar results which are as yet unpublished. Weisman et al.[13] and Ellison and co-workers[14] have confirmed these results both on animals and man. On the other hand Billingham[15] and Morgan[16] have noted prolongation of life of homografts, three or four times longer than controls in rabbits treated with cortisone. However, the grafts finally sloughed in the usual manner so that no practical method of obtaining permanent survival

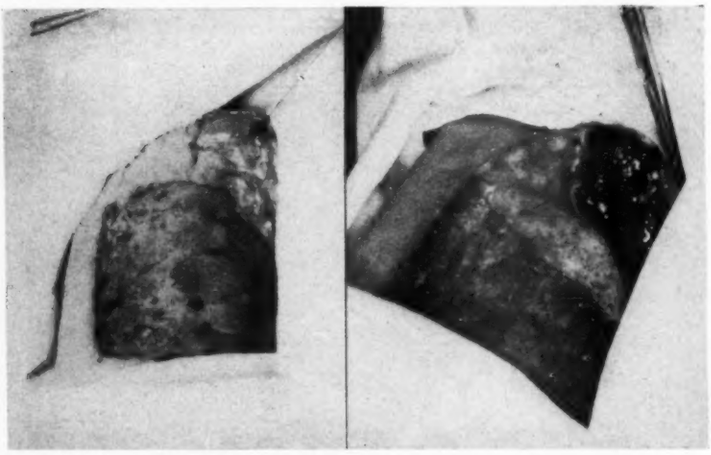

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FIG. 5. Auto and homograft eleven days postoperatively; pretreatment with 200 mg. of oral cortisone daily was started seven days before skin grafting and was given daily for twenty-four days. Beginning loss of epithelium may be observed.
FIG. 6. Auto and homograft seventeen days postoperatively, continuing on 200 mg. cortisone daily. Note that only a few shreds of dermis remain.

of homografts of skin in animals or man has yet been discovered.

BURNS

It was first suggested by Crassweller and co-workers[17,18] that cortisone therapy might be useful in burns because of clinical evidence of adrenal exhaustion in severely burned patients. Whitelaw[11] has claimed that adequate use of ACTH in severe burns either eliminated or appreciably reduced the phenomena usually present in severe burns in man. Others have reported favorably on its use in severe burns. Adams et al.[19] found that with the use of ACTH in three burned children fever was reduced and there was marked improvement in food intake and in emotional status of the patients. Blocker[20] has reported the treatment of thirteen patients with cortisone, ACTH or cortisone followed with ACTH. He considered that some benefit was obtained in combating burn shock, improving urinary output and creating a feeling of well being. Fever was not reduced and the incidence of infection was increased. Several surgeons have reported the death of patients with burns who were receiving therapy with ACTH or cortisone, and some of these showed signs of generalized infection. Possibly metabolic disturbance or metabolite derangements may occur with high dosage of these hormones which are difficult to recognize or compensate. Further, it has been reported by Raker and co-workers that edema and blebbing of similar amount and duration to that of control patients developed in the burned areas of patients treated with ACTH. The same degree of edema and blebbing developed in patients with Cushing's disease due to hyperactive adrenocortical tumors and normal volunteers who received the same standard thermal burn. Similar results were obtained with pairs of young hogs, each pair receiving a controlled burn of increasing severity. This research indicates that ACTH cannot be substituted for the usual plasma, electrolyte and fluid requirements in severely burned patients. Nevertheless, if burns occur in individuals whose adrenals have failed to respond, then it is probable that ACTH or cortisone will be of benefit, depending upon circumstances. The use of these hormones in burn therapy should be cautiously explored until a sufficient number of reported cases will permit evaluation of their advantages and dangers.

MISCELLANEOUS CONDITIONS

Hume et al.[21] have reported on the use of ACTH and cortisone in fifty-six surgical patients. Those conditions responding most favorably to treatment were as follows: Patients with marked pituitary-adrenocortical

deficiency such as panhypopituitrism or Addison's disease who are undergoing surgical procedures. This was also true of patients suffering from acute trauma or chronic debilitating disease in whom surgery was necessary. When adrenal tumors are being removed, cortisone should be used before and after operation because of atrophy of the remaining adrenal gland. If complete bilateral, partial or total, adrenalectomy is being performed for hypertension, these patients must of course be maintained with cortisone. Certain conditions such as acute non-suppurative tenosynovitis, tendonitis and acute bursitis responded well. Several workers have firmly established the use of ACTH and cortisone in traumatic inflammatory conditions of the eye. Steinbocker[22] has reported improvement in patients with shoulder-hand syndrome and Moseley[23] has obtained similar results in his cases. Conflicting results[24–26] have been reported in the treatment of abdominal adhesions in experimental animals with ACTH and cortisone and further clinical investigation is desirable. A good deal of work has been carried out on hypertrophic scars and keloids, using parenteral or local therapy, but the results have on the whole been disappointing. We treated two patients with Dupuytren's contracture for two and three weeks respectively, with 200 mg. of cortisone daily. There was no relaxation of the degree of contracture or change in the histologic appearance of the palmar fascia in pre- and post-treatment biopsies. However, in a few cases of fasciectomy for Dupuytren's contracture we thought that there was possibly a more rapid return of free extension and flexion of the hand than usual, when oral cortisone was given postoperatively. In view of the fact that patients receiving ACTH or cortisone may show no fever, the white cell count may not be an accurate guide, abdominal rigidity may be reduced or absent and the patient's behaviour deceptive, the surgeon may be mislead in the diagnosis of acute abdominal conditions. Since the administration of ACTH or cortisone tends to repress the pituitary or both pituitary and adrenals, a sudden cessation of these drugs is often followed with a period of adrenal deficiency. It is probably dangerous to stop ACTH or cortisone if an individual requires to be operated upon during a course of therapy. The dosage may indeed have to be increased and gradually withdrawn postoperatively. These hormones should not be administered if the following conditions are present: diabetes mellitus, Cushing's syndrome, congestive failure, acne vulgaris, hypertensive cardiovascular disease, osteoporosis, pregnancy, chronic nephritis, hirsutism, psychopaths, history of peptic ulcer or tuberculosis.

SUMMARY

The use of ACTH and cortisone in surgery has certain positive indications whereas further investigation is required in other conditions.

Patients with frank pituitary-adrenocortical failure requiring operation or those with acute or chronic deficiency may be carried through an emergency by adequate therapy.

Although wound healing and granulation tissue production are delayed in animals, results in man vary and probably quite large doses of ACTH or cortisone are necessary to cause delay of granulation tissue formation in a high percentage of surgical patients. Although marked delay of wound healing in some surgical patients may be undesirable, in others it is most useful. For example, a delay of granulation tissue formation to minimize formation of adhesions about severed tendons, tendon grafts and following operations on the hand may be a most valuable therapeutic adjunct to operation. Similar studies should be undertaken on a most important problem, that of abdominal adhesions. Consideration of the physiologic actions of ACTH and cortisone suggested that they might be useful in the treatment of severe thermal burns. Clinical results, however, have been disappointing in a considerable number of instances. In view of the high mortality in extensive burns it would seem advisable to continue animal experimentation and carefully supervised studies on selected burn patients.

Treatment of hypertrophic scars and keloids and attempts to prolong the life of homologous grafts of skin have not been encouraging.

It appears that the role of ACTH and cortisone in surgical conditions is considerably broader than it was a year ago and its use in surgery may be extended still further.

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MANAGEMENT OF SHOCK AND CONVALESCENCE IN THE ELDERLY AND INFIRM*

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THE surgery of trauma in modern times consists in an orderly sequence of resuscitation, operation, convalescence and rehabilitation. This sequence is effective and unhesitating when the patient is the healthy young adult as epitomized by the wounded soldier. However, when the patient is elderly and known to be already infirm, a curious paralysis may overcome the thoughts and actions of his attendants, which results in the victim being deprived of the full benefits of modern surgical physiology. Differences of opinion arise among the attendants as to what resuscitation may be safely employed. The timing of surgery may become confused between haste to operate before the patient gets worse and an irrational form of procrastination. Subsequent convalescence is often allowed to run its course in fatalistic and negative observation, all setbacks and complications being attributed to the age and infirmity of the patient.

This article makes a plea for the aggressive correction of every remediable factor. In particular, it is believed that more use can be made of transfusion in the care of the elderly injured person than has been our custom in the past. Owing to the limitations of time the greatest emphasis will be placed upon the control of the circulating blood volume. Despite the limitations of our knowledge of the basic mechanisms of shock, we do know that the maintenance of the circulation is the primary point in the cycle to which we can apply active and rational therapy.

Considerations Affecting the Ability of the Elderly to Withstand Shock. A word must be said to emphasize the extreme importance of preventing the development of shock and hypotension in the elderly. In the first place, resuscitation from the shock state is more difficult and dangerous, due primarily to the earlier onset of fatigue in the autonomic nervous system, the endocrine system and the myocardium. In the second place, the likelihood of serious visceral damage taking place is very much higher than in the younger individual.

The most obvious result of hypotension upon the arteriosclerotic vascular tree is the development of thrombosis—coronary, cerebral and venous. In an excellent study by Davis et al.[1] it was demonstrated that the majority of their cases suffering coronary thrombosis after surgery showed a period of low blood pressure in direct relation to the operation, almost invariably related to the inadequate use of blood transfusion.

The resistance of the liver, kidneys and lungs to shock and anoxia is limited at the best of times. Since the pioneer work of Ravdin[2] it has become widely known that the well fed liver of good protein content is the best calculated to resist intoxication and anoxia. In many elderly people this favorable condition is lacking, and shock presents the danger of reaching irreversibility at an early stage. The dangers of tubular damage in the kidneys and congestive changes in the lungs are likewise more pressing.

Considerations Affecting the Blood Volume in Elderly Patients. It is of paramount importance to recognize that a reduced blood volume may have existed before the injury was sustained. Even in the absence of active disease, a decline in the nutritional status is a universal feature of old age.[3] There is ample evidence in the literature that chronic malnutrition carries with it a chronic reduction in total blood volume. In the emergency phase of injury nothing can be done to correct this general malnutrition, but its specific effect upon the blood volume is subject to some degree of correction. Clinical data still give us the best guide in assessing the importance of this factor. Each patient should be studied briefly from the viewpoint of a nutritional history, assessment of body weight changes during recent weeks or

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months, and the appearance and feel of the body musculature. The presence of specific preexisting disease, such as diabetes, gastrointestinal or other debilitating conditions known to be associated with a chronically negative nitrogen balance, will aggravate the inherent deficit.

In addition to this over-all deficit in blood volume, some degree of secondary anemia may be expected. A lowered hemoglobin reading per 100 cc. of blood, when viewed in relation to a reduced blood volume, may represent a serious reduction in oxygen-carrying capacity. A further blood loss as a result of trauma, perhaps of a degree which would disturb a young person very little, may render the elderly patient absolutely unfit for operation until he has been transfused somewhat liberally.

Enough has been said to indicate that a proportionately greater contraction of blood volume may exist in the elderly individual after trauma than in the previously healthy young adult. On the one hand the work of numerous authors[4] has shown us that we must expect a chronically diminished blood volume in the elderly and malnourished. Bigelow et al.[5] have published a recent study on the relation of blood volume to nutritional deficiency. They suggest as a guiding figure, in making a rough calculation of blood requirements on the basis of nutritional deficiency alone, that a deficit in blood volume of 50 cc. be considered to exist for every pound of recent weight loss. We have found this figure most useful in actual practice. On the other hand, such valuable studies as those presented before this association in 1950 by Dodds and Curry[6] and by Nelson and Lindem[7] have demonstrated that the blood loss even from closed fractures may be very considerable indeed. Accordingly, a patient who has a history of 20 pounds of recent weight loss, who then sustains an intertrochanteric fracture of the femur, may well have a deficit of 2,000 cc. in total blood volume—1,000 cc. on the basis of nutritional contraction before injury and 1,000 resulting from the fracture. When these two factors combine in the elderly injured person, blood transfusion becomes the most important preventive of circulatory collapse in the very patient least well fitted to withstand such collapse.

Management of Transfusions. If the prevention of shock and its early control is of such special importance in such patients, what is the basis for the current reluctance to use blood transfusions to the full? It is a fear of inducing a state of overloading, with resultant strain upon the heart and edema of the lungs. To what extent is this fear justified? It is justified to the extent that a real hazard exists in an attempt to take up the full slack of a contracted vascular bed as rapidly as is possible in young people. The answer lies in careful timing of the transfusion program. Large transfusions must be avoided within any narrow interval of time. In particular it is desirable to foresee the shocking effect of definitive surgery so that the necessity does not arise for giving large amounts of blood during the operation. In visceral surgery, with the possible exception of cases of gastrointestinal hemorrhage, the day is past when patients received heroic transfusions in the operating room to bring them back from shock states primarily due to inadequate preoperative transfusion. A plea is made that the same approach be applied to the injured person.

For example, it becomes clear that the administration of 2 L. of blood before operation may be highly desirable in a patient such as we have discussed who is suffering from an intertrochanteric fracture of the femur. It is also evident that operation will have to be delayed if such a quantity is to be given slowly in divided doses. No fixed rule can be given for the rate of transfusion which these patients will stand. Constant observation of the evidences of increased venous pressure, as seen in the neck and the arms, of the state of the pulmonary circuit as determined by observation of respiration, auscultation of the lung bases and the appearance of cyanosis, will furnish a guide as to when to slow or postpone the transfusion. With the protection of antibiotics it may now prove safer to defer operation in cases of open wounds until sufficient blood has been administered. We are now in a better position to balance the risk between uncontrolled infection and uncontrolled shock.

For the past three years in Montreal the Canadian Red Cross has operated a central blood bank which has been the sole source of blood for the majority of hospitals in the city. Blood donations are entirely voluntary and are absolutely cost-free to the patient. The success of this plan has been such that for the first time our patients have had all the blood they needed.

We owe a great debt to this service. Not the

least has been the change in attitude toward the supportive treatment of the elderly. Not long ago it was my impression, and one generally shared by many surgeons, that elderly people should have their definitive surgery after trauma either at once or about one week later. This view has now given place to a clinical impression that a delay of twelve to seventy-two hours is often highly desirable, provided the interval is employed in a gradual but persistent attempt to restore blood volume by transfusion. If each pint of blood is infused slowly, two to four hours being fast enough, and if a break of several hours is allowed between each bottle, there appears to be no danger. The work of Eaton[8] suggests that the most important single factor in the development of pulmonary edema and congestion in shock and impending shock is a loss of osmotic pressure in the plasma in the pulmonary capillaries. Theoretically, transfusion would tend to improve the plasma osmotic pressure and decrease the likelihood of pulmonary edema from this cause.

The clinical benefits of transfusion in these cases vary with the patient. Some are just too old to respond to anything. However, I have been struck by how much less old and hopeless many patients appear a few hours after transfusion. Often the clouded sensorium will clear, renal function will improve, color will appear in the cheeks and appetite will return. I have seen rales disappear from the lung bases following a transfusion which the medical consultant had advised against. In this connection I would counsel surgeons to avoid the temptation to take umbrage in the advice of their internist with regard to the use of transfusion. This phase of supportive therapy is the surgeon's responsibility. Nobody knows less about shock than the average internist.

Time prevents the presentation of detailed case protocols. Nor can much be said about the management of convalescence. Successful convalescence is largely a matter of careful psychologic and nutritional handling, and the two go hand in hand. Here again the blood volume is one point of attack which has a direct relation to appetite and well-being. Repeated small transfusions will be found most valuable. Supplementary vitamins, minerals including iron and calcium, and intramuscular liver extract are important elements of support. Encouragement of the greatest possible physical activity increases both appetite and hope, as well as aiding the local function of the injured part.

In summary, the appearance of hopeless frailty and exhaustion, which may characterize the elderly injured person, should not paralyze our actions. Many cases are suffering from a reduced blood volume of relatively greater degree than that which a similar injury would produce in a healthy young person. Assessment of the pre-existing blood volume deficit and its inclusion in the calculated transfusion requirement is a factor of vital importance. The fear of transfusion can be dissipated by wider experience with it, patience and careful timing being the watchwords to avoiding overtreatment.

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EARLY RECOGNITION AND MANAGEMENT OF SHOCK*

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TRAUMATIC shock is a clinical state characterized by varying degrees of peripheral circulatory failure. In most wounds and injuries it is dependent upon a reduction in blood volume plus any other anatomic and physiologic alterations produced by the trauma. Properly timed initial surgery of the wound or injury is an essential part of the management of shock. Ill advised or improperly timed surgical procedures may initiate or exaggerate shock.

ETIOLOGY OF TRAUMATIC SHOCK

Reduced blood volume:
- Whole blood loss (in the vast majority of wounds and injuries)
- Plasma loss (over and above that lost as whole blood) — Burns, crush injuries, gas gangrene, sepsis with exudation, peritonitis or pleuritis from gross soiling
- Dehydration

Factors leading to cardiorespiratory embarrassment:
- Blood and/or air in one or both pleurae; cardiac tamponade; cardiac injury; respiratory obstruction from blood, mucus or foreign body in tracheobronchial tree; laryngeal obstruction; flail chest with paradoxic respiration; painful rib fractures or chest wall wounds; dilated stomach; head injury

Neurogenic factors:
- Pain; fright; injury to central nervous system

Toxic factors

The important etiologic factor in traumatic shock is a decrease in the volume of circulating blood. In most instances this reduction in blood volume is brought about by the loss of whole blood. Tremendous loss of whole blood may occur in compound fractures of the extremities. As much as 2 or 3L. may be lost into the tissues in a simple or closed fracture of the femur. Multiple fractures involving the spine or pelvis have resulted in death from shock due to blood loss into the tissues. Often there is extensive loss of whole blood in wounds of the chest, abdomen or extremities. Determinations have shown losses of 40 to 75 per cent of the blood volume in those in severe shock. Those in mild shock have usually lost 20 per cent. Accurate measurement of blood loss in various surgical procedures have yielded surprisingly high figures. Cognizance of this is important in estimating blood needs for the wounded and injured in whom surgical intervention is an essential part of therapy.

Plasma loss in excess of that lost in whole blood does occur in certain wounds and injuries. Burn shock is due predominantly to the loss of blood plasma from the burned area. However, recent observations would indicate that even in burns the early need for whole blood is present. Extensive plasma loss also occurs in crush injuries, gas gangrene and other infected wounds with extravasation of plasma into the tissues or from the wound surface. In abdominal wounds and injuries accompanied with gross soiling of the peritoneum with feces or gastrointestinal content, plasma is lost through exudation from the serosal surfaces.

With allowance for the exceptions previously mentioned blood volume studies in patients with traumatic shock have shown depletion of hemoglobin or red cells to exceed that of plasma. This may be explained by a fairly rapid shift of plasma fluid from extravascular areas into the blood stream. A comparable compensatory reserve does not exist for the red cells. This factor further emphasizes the need for whole blood or red cells rather than plasma.

Dehydration may be present at the time of wounding or injury and frequently develops subsequently if proper attention is not given to fluid requirements.

Although reduction in blood volume is

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usually the important etiologic factor, there are often other factors resulting from the wound which will lead to shock. Chief among these are those factors leading to cardiorespiratory embarrassment. Hemothorax, pneumothorax, hemopneumothorax, tension pneumothorax, painful fractured ribs and paradoxic respiration in flail chest from multiple rib fractures may so interfere with the cardiorespiratory mechanism as to induce or exaggerate shock. Blood or mucus in the tracheobronchial tree and pharynx may do likewise. Laryngeal obstruction due to edema, hematoma or foreign body must be promptly relieved or death may result from asphyxia. Cardiac tamponade will lead to shock and death with comparatively small reduction in blood volume. A depressed fracture of the skull, extradural hemorrhage or increased intracranial pressure from any cause may lead first to slowing of the pulse and elevation of the blood pressure, but with an ultimate break in compensation comes a rapid thready pulse with lowered blood pressure and the clinical picture of shock. Acute dilation of the stomach, a not infrequent complication of any injury, seriously hampers the respiratory effort.

The exact role of pain as an etiologic factor in shock has not been definitely determined. The relief of pain, however, is important in its management. Use of the Thomas splint for transportation of injuries to the lower extremities not only serves to relieve pain but also to prevent further trauma to and hemorrhage from the tissues. In abdominal surgery traction on the mesentery of the small bowel leads to a fall in blood pressure. Other painful stimuli are known to do likewise. In the absence of other factors the blood pressure usually returns to normal promptly after cessation of the painful stimulation. Fright, the sight of blood and other obnoxious psychic stimuli may result in peripheral vasodilation with a fall in blood pressure. These neurogenic factors, when present, may seriously exaggerate the severity of shock due to reduced blood volume inasmuch as the latter is initially compensated for by vasoconstriction.

The exact role of toxic factors in shock is not yet known. They must play a part in late shock in infections and in some of the cases of so-called irreversible shock in which adequate blood replacement does not lead to restoration of normal blood pressure. A toxic factor may come from devitalized or necrotic tissue, bacteria or perhaps from the liver following prolonged anoxia. It is thought by some that a toxic liver factor may be the result of invasion of the anoxic liver by anaerobic organisms rather than from changes produced by anoxia alone. Toxic factors when operative produce shock by vasodilatation.

Symptoms and Signs of Shock. The symptoms depend not only upon the degree of reduction in the volume of blood but also upon the number and character of the complicating factors produced by the wound. The picture of uncomplicated shock is that of hemorrhage.

There is no one constant or reliable clinical index of the degree of blood loss. The blood pressure is perhaps the most reliable criterion. With slight to moderate hemorrhage a compensating vasoconstriction may maintain a normal or near normal blood pressure. With movement of the patient for radiologic study or surgery or with further bleeding, the blood pressure may drop precipitously. In severe hemorrhage the blood pressure may be so low it cannot be determined in the arm. Frequently the patient with 0/0 blood pressure on admission to the hospital will show immediate improvement when the foot of the litter is raised and the wounded parts are kept at rest. The pulse pressure rarely shows any significant decrease until there has been a significant drop in the systolic blood pressure. The pulse rate is not nearly so reliable as the blood pressure in estimating the degree of blood loss. Frequently those with low blood pressure will show a normal pulse rate. Most, however, do show an increase in the pulse rate as the blood pressure falls. In severe shock the individual is usually pale, white or ashen. The veins are collapsed. He seems to be suffering no pain but complains of thirst. Apathy develops but consciousness remains until the pressure has been extremely low for a long period of time. Sweating is not frequently encountered. There may be some air hunger in the individual with uncomplicated shock. Appraisal of the number and extent of the wounds or injuries is often very helpful in estimating the degree of reduction in blood volume. Response to therapy is likewise of value.

When factors leading to cardiorespiratory embarrassment are present, the symptoms will vary accordingly. Hemothorax and pneu-

mothorax may lead to dyspnea or orthopnea and occasionally cyanosis. Inspection, percussion and auscultation will usually establish the diagnosis but a radiograph of the chest is always helpful. Painful chest wall wounds or multiple rib fractures may seriously limit the respiratory excursions and prohibit effective coughing so that secretions, blood or exudate may accumulate in the tracheobronchial tree. With cardiac tamponade there is lowered blood pressure with greatly diminished pulse pressure, distant or absent cardiac sounds and distention of the veins of the neck and upper extremities. In laryngeal obstruction there is pronounced dyspnea, often with laryngeal crowing and retraction of supraclavicular, infraclavicular and intercostal spaces with inspiration. Paradoxic respiration in flail chest is easily recognized by inspection. A dilated stomach is often overlooked but should be recognized from the abdominal signs and from the elevation of the left diaphragm indicated by high gastric tympany.

Recognition of possible neurogenic factors presents no problem. The possibility of toxic factors in shock must be constantly borne in mind, particularly with reference to the development of gas gangrene or sepsis in wounds.

Differential Diagnosis. Well developed traumatic shock must be differentiated from acute cardiac failure. It is seldom a problem in warfare where the patients are nearly all from a group of carefully selected young adult males. It is seldom a problem when a history can be obtained and when definite evidence of trauma is apparent. In severe circulatory failure, be it peripheral or central, the individual often cannot give a history. If there is no external evidence of injury and no history can be obtained, careful though rapid study of the patient must be made before starting fluid, plasma or blood infusions as these would be most harmful in acute cardiac failure. Distended systemic veins or pulmonary edema with dyspnea characterize acute cardiac failure and are not seen in uncomplicated shock. However, with many chest injuries and wounds dyspnea and pulmonary edema or excessive mucus or blood in the tracheobronchial tree may be present. Distended veins in the neck and upper extremities are seen in cardiac tamponade or hemorrhage into the mediastinum, obstructing the superior vena cava. In cardiac failure one usually finds arrhythmia, increased cardiac dullness, perhaps enlargement of the liver and other signs of cardiac disease. In shock evidence of trauma can usually be found on careful investigation. A radiograph of the chest is always helpful.

Traumatic shock must also be differentiated from pulmonary embolism, poisoning from barbiturates, alcohol or morphine and coma from head injuries.

TREATMENT OF TRAUMATIC SHOCK

There are no useful laboratory guides in the treatment of traumatic shock. The clinical judgment of the attending physician must determine and time the management. The physician who sees the patient at the scene of the injury, or in an area distant from hospital facilities for surgery and blood transfusion, must use the rarest judgment of all.

Management of Traumatic Shock before Admission to Hospital. Place the patient in supine position. If the systolic blood pressure is below 85 mm. Hg, lower the head of the litter 12 inches. If a chest wound is present and lowering the head increases the respiratory difficulty, leave the litter level. If head or chest injury is present and the blood pressure is normal, elevate head slightly. If a maxillofacial injury with bleeding is present, place in the prone position.

Venous hemorrhage is best controlled by local pressure. Arterial bleeding is best controlled by ligature or by the application of a hemostat. A tourniquet may be safely used to control arterial hemorrhage in an extremity if the journey to the hospital is not a long one and can be accomplished quickly. When a tourniquet is applied to control arterial hemorrhage, it should not be loosened or removed until the bleeding vessels have been tied or until blood transfusion has been started so that any further blood loss may be rapidly replaced.

Apply dressings of sufficient size and thickness to all wounds to serve until the patient is in the hospital and ready for surgery. Dressings on all chest wounds should be firmly strapped in place to occlude the wound effectively whether or not the wound is sucking at the time of the dressing.

Fractured or wounded extremities must be properly splinted.

Insure an adequate airway. Encourage the

patient to cough up any blood and mucus in the tracheobronchial tree. Very rarely tracheotomy for laryngeal obstruction must be performed before the patient can be transported.

If pain is present, give a small dose of morphine sulfate intravenously. Intravenous administration is important because in shock morphine is absorbed very slowly if at all when given subcutaneously or intramuscularly. With a normal blood pressure, after resuscitation from shock, it is absorbed rapidly; and if repeated doses have been given, morphine poisoning may result.

Conserve body heat by placing an adequate number of blankets both under and over the casualty. Do not use external heat.

If the hospital is distant and the systolic blood pressure is below 80 mm., delay evacuation until transfusion of blood or plasma is started. Plasma and blood are used only in the smallest amounts necessary to insure the patient's arrival at the hospital alive and without irreparable damage from prolonged shock.

Rarely one encounters a tension pneumothorax which must be relieved by the insertion of a needle or catheter into the second interspace anteriorly. The needle or catheter should be attached to a flutter valve made of a condom or a long strip of Penrose tubing. An occasional case will require aspiration of blood and air from one or both pleural cavities before transportation can be safely attempted. Cardiac tamponade is rarely encountered. It is usually best to move the patient to the hospital immediately rather than to aspirate the pericardium before transportation.

Record all medications, plasma, blood, blood pressure readings and other pertinent data, giving hour and date.

Evacuate as rapidly as possible to a hospital where facilities for transfusion and necessary surgery are available.

Management of Traumatic Shock after Admission to Hospital. All indicated measures must be carried out rapidly. The following may serve as a useful guide:

Note pulse rate and volume, respiration, color of skin and mucous membranes, and determine the blood pressure. Position the litter as previously described. Remove all clothing by cutting away. (This may be started while physician is carrying out the first measure.) Place an adequate number of blankets both under and over the patient. Make a careful but rapid and complete physical examination to determine the extent and nature of all wounds and injuries. Check all wounds to be certain bleeding has been controlled. Make certain that all chest wounds are adequately dressed and occluded so that there is no ingress or egress of air from the pleural cavity. Make certain that the airway is clear. If the patient cannot cough up mucus and blood from the tracheobronchial tree, endotracheal catheter suction should be used. If this is not successful, bronchoscopic aspiration may be indicated. If severe laryngeal or tracheal obstruction is present, perform tracheotomy and immediately clear tracheobronchial tree by catheter suction.

Start intravenous therapy. If pressure is 0/0, one may give 500 or 1,000 cc. of low titer group O, Rh negative blood without cross matching. It is always wise to cut down on a vein and insert a cannula within it so that the blood may be given rapidly. If shock is not so severe, one may start electrolyte solution or plasma infusions while cross matching is being accomplished. Blood is infused rapidly giving as much as 500 cc. in five minutes or 1,000 cc. in ten minutes. The rate of infusion should be slowed when the systolic blood pressure reaches 85 mm. Hg. If one can be certain that all bleeding has been controlled, it is well to give 500 cc. more blood after the systolic blood pressure has exceeded 100 mm. Hg. If one cannot be certain that bleeding has been controlled and a backlog of patients prevents immediate surgery, blood should be given only in sufficient quantity to maintain a systolic blood pressure of 100 mm. Hg until such time as surgery is undertaken. If the patient is not in shock but the extent of the wounds or injuries indicates significant blood loss, give at least 500 cc. of blood before starting anesthesia.

Oxygen therapy should be started promptly in all cases with severe shock or chest wounds with dyspnea. Relieve pain from chest wall wounds by injection of 5 cc. of 1 per cent procaine hydrochloride about appropriate intercostal nerves. With relief of pain the patient will frequently be able to cough up blood and mucus from his tracheobronchial tree which he has been unable to raise before. If pain is present and morphine has not been administered prior to the hospital admission, a small dose may be given intravenously.

Atropine or scopolamine should always be administered before anesthesia.

Aspirate hemothoraces and pneumothoraces using a 16 gauge needle attached to a vacuum bottle containing citrate. (A syringe and three-way valve may be used in lieu of the vacuum bottle.) Remove all air and blood. If pneumothorax or a large bronchial fistula persists, introduce a catheter through the second interspace anteriorly and connect with a water seal bottle. Aspirate hemopericardium and immediately move the patient to surgery so that emergency thoracotomy may be performed if bleeding into the pericardium continues. All blood from pleural and pericardial sacs should be collected aseptically so that it may be used for autotransfusion.

Relieve dilation of the stomach by passing a nasogastric tube. Vomiting should be induced by the passage of the tube and suction should be applied for drainage after it has been passed. Prior to anesthesia one must be certain that the stomach is empty. If the casualty had eaten within four or five hours of the time of wounding, the passage of a nasogastric tube prior to anesthesia is indicated.

Surgery is performed at the optimum time. In those cases responding well to resuscitation therapy normal blood pressure is best attained before moving the patient to the operating table. In those who show no response to the rapid infusion of 1,000 cc. of whole blood prepare for emergency surgery to start about the time the administration of 1,500 cc. of blood is completed. Intra-arterial transfusion is most valuable in cases of this type. Transfusion should be continued at the indicated speed throughout surgery. All blood losses incurred by the surgical procedure should be replaced as the losses occur. Enough additional blood should be given during and immediately following surgery to avoid the possibility of a recurrence of shock. As a general rule, administration of 500 to 1,000 cc. of blood above that needed to attain a normal blood pressure is indicated. In those cases in which surgery establishes peritoneal contamination or infection as the shock-producing factor and there has been little blood loss, plasma may be used instead of blood. In the case of multiple wounds, chest wounds should be repaired first. (There are rare exceptions.)

The infusion of 5 per cent dextrose in water before and during surgery is indicated to combat dehydration and to provide an adequate fluid intake. As a rule the dextrose solution may be started in a second vein whenever the systolic blood pressure has reached 80 or 85 mm. Hg. Proper fluid therapy will help prevent some of the lower nephron nephroses which tend to develop following prolonged shock.

Urinary output before, during and following surgery should be measured and recorded. Adequate blood, plasma and fluid therapy should provide a minimum urinary output of 40 cc. per hour. Those in shock with wounds or compound fractures should be given large doses of penicillin early. It is best given intravenously until shock has been corrected.

DISCUSSION OF PAPERS BY DRS. BAXTER, SCHILLER AND WHITESIDE, GURD, AND SNYDER

JAMES M. WINFIELD (New York, N. Y.): As Dr. Griswold intimated, Dr. Snyder's paper is a general résumé of a subject which I think is most controversial. Dr. Gurd said the internists know little or nothing about shock. Frankly, I do not think the surgeons know much more. Certainly I do not.

Dr. Snyder was correct in emphasizing the importance of blood. I think there are too many people in this country who do not realize the importance of adequate replacement, that is, when a person has lost blood, of giving blood. Obviously, if there has been gross hemorrhage, blood is the best thing we have to replace that loss but the whole field of electrolyte balance is in the clouds. You can give all the hemoglobin in the world and if it cannot be transported through the extracellular space to the cells, through the cell membrane, it will do no good.

Here is what I am driving at: Many patients are given glucose in water. We must replace electrolytes; and if you do not have your sodium, potassium, chloride, calcium, magnesium, etc., you will not get the oxygen into the cells.

We must in some way give electrolytes that are proper at the same time that we give blood. The so-called physiologic saline is not good. It is too high in chlorides, possibly too high in sodium, certainly too high in chlorides in relation to sodium as present in plasma. Therefore, a more balanced solution of electrolytes has to be devised, given with blood to facilitate the transport of oxygen from the hemoglobin-carrying red cells through the extracellular space and cell membrane to the cells themselves.

If you cannot get the ideal solution, 6 molar

sodium lactate, Hartmann's solution and Ringer's lactate approximate the proper balances. They are far safer to give, I think, than glucose in water because you are simply washing out whatever you have if you give glucose in water. With blood you should think of the electrolytes and give the two together.

WARREN H. COLE (Chicago, Ill.): All of us agree, of course, that shock and blood replacement are very important to a surgeon regardless of his specialty. It was emphasized by Drs. Gurd and Snyder that meticulous care in active replacement of blood will repay you with very good results in convalescence and mortality rates.

I should like to emphasize two points. First, we should not subject the patient to a major operation without being sure that we have a good preoperative blood balance. I have too often seen patients go to the operating room with mild anemia while the surgeon says, "I will replace that on the operating table." It means the patient may get 4 or 5 pints of blood on the operating table when he should have had 2 or 3 pints two or three days before. I am quite certain that making up preoperative blood volume deficits on the operating table is a bad policy; correction of blood volume deficits should be made twenty-four to forty-eight hours before a major operation in order to obtain maximum benefit from repletion.

The other point which I wanted to bring out was the difficulty in the diagnosis and treatment of internal hemorrhage in the immediate postoperative period. I will never forget a situation in which I missed a diagnosis two or three years ago. The patient had had a gastrectomy. It happened I did not do it but I saw the patient three hours afterward, at which time a very strange condition developed which I should have recognized but did not. He became very restless, had an irregular pulse, was cyanotic and almost delirious; we thought he was having some strange pulmonary complication. We delayed proper therapy and lost him; at autopsy we found he had a massive intraperitoneal hemorrhage. I still think that from the signs presented an accurate diagnosis might be considered difficult; perhaps if we had had a really good test for blood volume we might have been able to make the correct diagnosis. As you know, hematocrit and hemoglobin determinations are worthless in the diagnosis of hemorrhage of only three or four hours' duration. Blood volume studies are much more accurate, but still so inaccurate that I am hereby making a plea for research workers to attempt perfection of better methods.

GEN. SAM F. SEELEY (Washington, D. C.): I have enjoyed these papers very much. With reference to Dr. Baxter's paper, I think that in any case in which the patient receives ACTH or cortisone there should be laboratory control of the drug's efficacy. We use the eosinophil counts and 17-ketosteroid concentrations in urine when we try to reduce the number of intra-abdominal adhesions with cortisone. Furthermore, administration of these drugs should not be instituted without two warnings being voiced again and again. The first is relatively asymptomatic perforation of duodenal ulcer, which is a very real hazard. Anyone who is known to have had an ulcer or who may be suspected of having one should not be given these drugs. The second is the tendency toward suicide in those who might be mentally ill or have the drug abruptly withdrawn. I know of one instance of a woman who committed suicide after receiving cortisone to prevent intra-abdominal adhesions.

I think the point made by Dr. Cole is very important, that is, blood volume determinations. We need a blood volume measuring stick which can be run *serially*. We never know the degree of vasodilatation or the degree of vasoconstriction in the vascular tree, so that even when we have what we think is a balance between plasma and cells, we do not know how much whole blood there is in that vascular tree.

One practical method which we have used in intra-arterial transfusion is the balancing of a receptacle of blood attached to the artery of the patient at a desired level, say approximately 6 feet above the heart of the patient, which will insure a systolic blood pressure of 120 mm. Hg. If the patient needs blood to attain this pressure, blood will run in. If the patient does not need blood, it will backflow into the receptacle and one can then interrupt its outflow. This has proven valuable and much work has been done in deliberately reducing the blood pressure to low levels, particularly in anticipating hemorrhage in intracranial operations.

MARTIN C. LINDEM (Salt Lake City, Utah): I would like to have Dr. Gurd, if he will, elaborate somewhat upon his method of determining the blood volume in these elderly patients, whether he uses the Evans blue method or not. We have now run, including those reported in the papers that were given last year, approximately 400 determinations by the Evans blue method in a group of cases which includes chronic ulcers, nodular thyroids, and nutritional disturbances that have to do with the gastrointestinal tract dysfunction and we find, coordinate with the weight loss, a blood loss of from 1 to 2 L. It is remarkable that the walking shock patient can show such a considerable blood deficiency, according to calculation and not exhibit the loss in his attitude toward his work.

In industrial occupations we find a lot of people who are working but are deficient in blood. If these people are subject to injury, they are very poor subjects for surgery; they go into shock unless the condition is recognized and corrected. The Evans

blue method has proved a very accurate index for measuring the blood that needs to be replaced.

THOMAS B. QUIGLEY (Boston, Mass.): Drs. Baxter, Schiller and Whiteside have given us an excellent résumé of the present status of ACTH and cortisone in surgery. At the Peter Bent Brigham Hospital in recent years we have been interested in these agents in all sorts of surgical and medical conditions. Our studies have included several severe burns. There is no doubt that ACTH and cortisone are *not* substitutes for proper restoration of electrolyte and blood balance. Whatever good they may do, they are not shortcuts to evaluation and treatment of the patient as a whole. This cannot be emphasized too strongly in view of certain publicity in newspapers and magazines which has occurred in the past year.

LESTER BREIDENBACH (New York, N. Y.): There is no doubt that we are using a lot of transfusions and there is very definite indication for it, but a word of caution must precede all this. I do not know how cognizant most of you are of the dangers of transfusion. In the past year in one of the hospitals in the city of New York there were two cases in which improperly typed and cross matched blood was given to the patient, of course resulting in death. When this happened I inquired around to find out whether this was a common occurrence or whether it was just one of those things that happened at one hospital. You know that the personal equation is a very important thing: There can be a mistake in the typing of the patient's blood; there can be a mistake in the cross matching of that patient's blood; and then you can have a third mistake in which a patient's name is put upon a bottle improperly and the anesthetist or whoever is responsible for administering the blood does not match it with the name on the chart and, again, the patient gets an improper transfusion.

It was said after I investigated and tried to get some figures throughout the United States that this type of thing happens 5× in every 1,000 transfusions. The figure was startling to me but apparently it is a correct one, that in five of every 1,000 transfusions in the United States a mistake of some kind happens in which the patient gets improper blood and, of course, the mortality is almost 100 per cent no matter how these patients are treated.

HARRY E. MOCK (Chicago, Ill.): It is only fitting that a man approaching that state known as "elderly" should discuss this paper, especially if he has had a personal experience such as I have had. I think my experience was sent to me because for years I have had an incompleted paper on rare intra-abdominal injuries following all kinds of injuries to the body, especially to the chest.

In October, 1949, on my sixty-ninth birthday, I awakened in the morning with the most terrific pain a man can imagine. Three weeks prior to that I had been in an automobile accident in Marion, Indiana. The wheel hit me in the abdomen. In addition, three cracked ribs and a little crack in the sternum were found. When they tried to move me out of the car, the pain was so terrific and my breathing was so difficult, I insisted on an ambulance.

At any rate, when I got to the hospital, Marlo Davis of Marion was waiting. When I was asked what happened, I said, "I have a ruptured liver."

He answered, "You surgeons always do diagnose the worst thing."

They x-rayed me and found the cracked ribs but no evidence of a ruptured liver. It is easy to visualize abdominal pain and rigidity from referred pain caused by fractured ribs. I have done this several times and allowed one intra-abdominal injury to continue one week and one injury to go to death and autopsy by blaming it on fractured ribs.

After twelve days I was allowed to go home. I had an indefinite discomfort in my abdomen and was getting along. I even went down to the hospital and did a little work; then on the morning of October 27th the terrific pain developed. My blood pressure was 200/0. The pain was so terrific that morphine was given. By the time I was taken to the hospital, I had no blood pressure. About six or eight blood transfusions were given, and I can testify to feeling better after receiving the transfusions.

However, I soon became irrational and sixteen hours went by before any blood pressure could be obtained. I was told on the way down that when at last my pressure was raised systolic to 90 and diastolic 80, with a pulse pressure of 10, knowing that they had to go into the abdomen the anesthetist was finally convinced to risk the anesthetic that he had refused all the time.

The interesting thing about this is those rare intra-abdominal injuries that are easily overlooked, for example, torn mesenteries, slowly developing stenosis of the bowel from the tear opposite the mesentery and similar things. My injury turned out to be a tear in the omentum, a simple thing you would think, but it was large enough so that slowly and gradually the large loop of the ileum had herniated through the tear into the omentum and at operation a large, gangrenous, dilated, juicy loop of the ileum obtruded through the abdominal wall as soon as it was opened and 40 inches of the ileum had to be resected.

The blood transfusions during that operation, continued for the next two days, undoubtedly saved my life; however, I want to put emphasis on the other life-saving thing. I got a great kick out of studying my chart during my convalescence. We have not dwelt enough upon the use of oxygen

in this. I saw it on the chart in Dr. Snyder's paper and I know he will agree. The oxygen that was given before and after carried me through that period when I thought I never could take the next breath.

Finally I was given a great deal of penicillin and aureomycin; and because when I had my throat operation I proved to have an allergy for or reaction to penicillin, to prevent a similar episode a great deal of parabenzadrine was given to me.

I was discharged from the hospital in six weeks and was home just a week when, lo and behold, chills and fever developed. I remarked I bet I did not have any polymorphonuclear cells. It turned out I had one old gray-bearded polymorphonuclear. You want to think of agranulocytosis when you use too much parabenzadrine.

Robert Mayo Tenery (Waxahachie, Tex.): I would like to make one short remark concerning seriously injured patients, especially those such as we see in Texas from our type of driving. One of the first things my father taught me in the care of the seriously injured patient is to do in the beginning only those diagnostic procedures which will influence treatment. Too often I have seen patients treated, especially in the smaller communities, where they have been x-rayed from head to toe before any treatment of shock was instituted. The patient may come in with a severe intra-abdominal injury or with a severe laceration and blood loss, at the same time perhaps complains of some pain in the back, jaw or chest. We still have a stethoscope to determine if the lung is functioning, and we can palpate broken ribs or mandible; but it will not influence our treatment to take an x-ray. Barton's bandage will hold the mandible until films can be made safely. Frequently an energetic medical staff precipitates traumatic shock.

Hamilton Baxter (closing): In commenting on General Seeley's remarks I am afraid I overlooked several slides. In wound-healing cases we studied the doses in relation to eosinophils, euphoria, blood pressure and weight. We also carried out studies on the nitrogen balance, ascorbic acid metabolism, gluco-corticoids and formaldehydeogenic corticoids in the urine.

With regard to the contraindications for therapy with ACTH and cortisone, those mentioned by the discusser should be observed. To these we must add a history of active tuberculosis because several authors have reported reactivation of this disease following therapy with ACTH or cortisone.

Fraser N. Gurd (closing): Dr. Winfield was perfectly right in raising the question of electrolytes in the treatment of shock. However, I would like to say that in the elderly injured person the biggest danger from our recuscitative measures is certainly the development of pulmonary edema or massive congestion, congestive atalectasis, or whatever we wish to call that serious complication. I think that if we have no positive evidence that the patient is in grave electrolyte deficiency, it is probably wise to avoid the use of nonprotein-binding crystalloids, particularly electrolytes, in the early stages of treatment. The safest thing, I think, is blood. The next safest thing is plasma. The most dangerous of all is the so-called physiologic saline solution; and if we do not know what we are doing with the electrolytes, I think we had better wait until we are sure that we need them.

In answer to Dr. Lindem's question as to what I really knew about blood volumes in these patients, the answer is that I have had no first hand experience with blood volume determinations in this type of case. I have relied in my statements about the deficits following injury very largely on papers such as Dr. Lindem's. I would just like to make it clear that I am making no particular apology for this deficiency in my work-up of these cases because I think that there are two serious deficiencies in the ordinary Evans blue type of blood volume determination. One is that we have to take an arbitrary standard for the optimum blood volume in the patient we are studying. The second is that we do not know, on the basis of these determinations, exactly how far to go with our treatment because we cannot run them serially in a satisfactory way.

Therefore, as I pointed out extremely briefly in this short time, I think if we will study simply the clinical picture that the patient presents together with what history we elicit, we can get a fairly good idea as to whether he was primarily deficient in blood volume before he was ever injured; and then, as to when to stop replacing that deficiency, we are no worse off on clinical grounds than we are if we have the finest laboratory right at our elbow. We have to stop as soon as we think we have gone far enough. I know that is an unsatisfactory answer, but if anyone has a better one, I would like to hear it.

Howard E. Snyder (closing): I should like to say first I enjoyed Dr. Gurd's paper and agreed with nearly everything he had to say. I think it goes into some of the details that one must consider in the application of the principles of the management of shock. I think both Dr. Gurd and Dr. Winfield brought out a good point: We do not know all we should like to know about the electrolytes and the use of fluids in these patients. I have been inclined to think that we have swung a little too much to the dehydrating side, particularly in the management of our surgical patients. We have done some work which shows that, particularly in young individuals, there is diuresis in the twenty-four hours preceding surgery. In the hour

and a half immediately prior to surgery, when the patient is under sedative, that diuresis has disappeared and the urinary output is very low. As we practice the use of intravenous fluid in our surgical patients, starting immediately with the operation, we have found a greater urinary output during surgery than in the period immediately prior to it.

Certainly saline or glucose in water, whatever solution we are using, should not be used with the idea of replacing lost blood volume but, again, certainly we must keep in mind the fact that the patients who go to surgery late in the morning may have had no fluid since the previous day. They are dehydrated because they have not had a drink and we should certainly supply their normal fluid requirements. I think that point is apropos in Dr. Cole's reference to the making up of blood volume deficit at the time of surgery. It is particularly dangerous then because it is apt to be done in the dehydrated patient.

I should like to thank General Seeley for his reference to arterial transfusion and call your attention again to what you all know, that he is responsible for this very useful tool. The paper did not have time to go into the details of that, and of course details are available.

The doctor who made the comments concerning too much diagnosis certainly hit a good point. It was demonstrated time and again during the war that the patient who was moved to x-ray or surgery often had a fall in blood pressure if he had not had enough resuscitation therapy or blood restoration prior to that time. Make that point but still stress the fact that the patient can be examined completely with the stethoscope and the tools he mentioned so that we do not overlook an important wound which may be contributing to the shock.

TRAUMA—A FACTOR IN INGUINAL HERNIA

WITH A BRIEF DESCRIPTION OF A NEW METHOD OF REPAIR

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DESPITE the many excellent contributions in the literature by Moorhead[1] and others in which it is rather conclusively shown that no single trauma can cause an inguinal hernia, there are certain aspects of this condition in which trauma plays a part. Very rarely trauma plays a direct role. McWhorter[2] describes a case of a boy who was struck in the groin by the handlebar of a motorcycle. He suffered a subcutaneous rupture of the external oblique fascia and the conjoined muscle was torn so that a hernia developed almost immediately. Maxeiner and Hoffert[3] reported the case of a man who fell 60 feet landing on his heels and suffered, besides numerous other injuries, an inguinal hernia. When this was repaired, the bowel was found to lie outside the peritoneum, there being no sac in the ordinary sense of the word. In one of my own patients who apparently had been perfectly well for five years following femoral hernia repair recurrence developed within a week after he sustained a severe blow over the groin. Aside from these rather extreme cases there are fairly numerous incidents in which an obviously preformed sac is filled for the first time by the abdominal contents. I have personally seen three cases of partially undescended testicle in adults in whom the first intimation of the presence of hernia was a sudden onset of strangulation. In each of these cases there had not even been a suspicion of hernia before and in each case violent exertion (an automobile collision or fall) preceded the onset of symptoms. It is also a fairly common observation that hernia in a child may first appear when he jumps down from a height. A typical case history follows:

R. F. L., a nineteen year old boy of foreign extraction, went to work for the N.P.T. Railroad in June, 1951. He had had a pre-employment examination in June, 1950, and again in June, 1951. At neither examination was a hernia found. His own history and his family denied any antecedent hernia. About two months after starting work, while icing a car, he was pulling as hard as possible on a 300 pound block of ice and the bar slipped off. He felt something pull in his right groin and then a burning sensation there. He sat down because his right upper thigh felt stiff and numb. He then detected some swelling in his right groin which was not formerly present. This swelling subsided but returned on slight exertion three days later.

The first factor in the causation of hernias is the anatomy of the inguinal region. Omitting incisional and umbilical hernias, practically all hernias are in the inguinal region. Of the inguinal hernias about 90 per cent are indirect. The upright position of man and the weakness of this region are responsible for this. In approximately 10 per cent of all males there is a preformed sac. About an equal proportion of adults will show a rather wide open inguinal ring with poor fascia. When these two anatomic weaknesses occur together, hernia is most apt to develop. The sac which is found in the usual indirect inguinal hernia and which may extend clear down into the scrotum is usually acquired. The infantile or congenital type of sac is in communication with the tunica vaginalis and easily recognized. There are, however, certain cases of hydrocele of the cord which do not communicate with the testicle or the abdomen and which illustrate that cell rests along the course of the cord may later produce sac-like structures. On several occasions I have found a good-sized hydrocele of the cord separated from the peritoneum by a thin diaphragm at the internal ring. Some of these had a small perforation of this diaphragm. It is easy to see how this diaphragm might suddenly be ruptured and a full blown hernia produced where none had been previously. It is now fairly well established that in almost all men there is a small funicular process in the internal ring. This is the starting point of an indirect hernia.

The second factor which influences the formation of a hernia is an increase of intra-abdominal pressure. The most common forth-

right example of this is the development of bilateral inguinal hernias in a patient with ascites. It will be seen that the pressure here is long-standing and the factor of trauma is not applicable. In an effort to ascertain whether any extremely violent changes in intra-abdominal pressure were capable of causing hernia a review of a number of cases of traumatic asphyxia was made in the hope of finding some cases of hernia production. The findings were more or less in agreement with Moorhead's that crushing injuries cannot be expected to cause inguinal hernia. On the other hand, there were two personal cases and a third in the practice of a colleague in which the intact jejunum had been ruptured intra-abdominally over a known hernial opening. In each of these cases there was violent abdominal trauma such as an automobile accident or a fall onto the abdomen across a log. In each case the bowel was apparently inside the abdomen at the time of the injury and a small perforation occurred on the antimesenteric border of a loop of bowel which apparently lay against the hernial opening. This amount of increased pressure, one would think, might be great enough to start some viscus through a weakened part of the abdominal wall.

The amount of pressure which can be built up within the abdomen, especially in the unprotected inguinal region, is a rather debatable matter. Anybody who has experienced the difficulty of having to close the abdomen when the patient strains and vomits is aware of the force which may be exerted. In lifting heavy objects in the erect position and particularly with the legs spread apart, there is very considerable pressure applied to this area. If one accepts the theory that there is a shutter-like action at the internal ring and that there is a reflex closing of this shutter when the abdominal wall is tensed, it is conceivable that under certain circumstances with a slip or a fall, when pressure is thrown on this area, the funicular extension of the peritoneum here may be unguarded by its normal supporting mechanism. It seems more likely, in the absence of a definite performed sac, that the combination of repeated trauma plus weakening of the tissues, due to age, infiltration of fat, etc., produces a potential weak spot and that eventually a final trauma gets the sac and a small amount of viscus clear through the internal ring. Once the sac with a viscus inside it has gotten through the internal ring it progresses down the canal at a rate which averages approximately 2 inches every six months.

What has been said previously applies particularly to indirect hernias. Direct hernias are more likely produced by aging with deterioration of the tissues and continued recurrent increases of intra-abdominal pressure due to constipation, chronic cough or occupation, etc. Here again a final lift or effort may start the peritoneum through the thinned-out elements of the fascia in Hesselbach's triangle.

Whether one accepts the element of trauma or not, there certainly is a tendency to recognize hernia as an occupational hazard or disease and to allow medical care for a hernia which is "developed on the job."

With the improvement in surgical technic, anesthesia and various therapeutic adjuncts there are now scarcely any contraindications to the repair of hernia. In fact, at the University of Oregon Medical School Hospital the incidence of strangulation of hernia among the aged was so great that it was deemed advisable to repair all hernias encountered regardless of the age or health of the patient.* Repair of hernia in the aged is different from repair in the young, vigorous workman. In the aged castration may be inevitable if recurrence is to be avoided, particularly with a large abdominal defect; in infancy the cure of an inguinal hernia by the simple removal of the sac is almost invariably successful. This latter method does not produce a permanent cure for the active laboring man who has a hernia after he is an adult. In these patients great precautions must be taken to prevent a recurrence effectively.

The innumerable articles in the literature on the treatment of hernia attest the fact that no final word has been written on repair of hernia. The evolution of the repair of hernia has actually been a gradual modification of the original Bassini[4] or Halsted[5] operations. Various plastic procedures have been devised to reinforce the abdominal wall by sliding adjacent tissues across the defect or by using grafts of fascia, skin, muscle or using inert foreign materials to fill the defect. The ability of the body to accommodate itself to some foreign material should not detract from the basic surgical principles involved. If a proper plastic pro-

*T. M. Joyce. Instructions to Attending Staff, 1947.

cedure can be performed enabling the inguinal region to be strongly and permanently reinforced, there is no necessity or desirability for the use of foreign material other than the necessary sutures.

The two principal weak spots through which herniations recur are opposite the subcutaneous ring in Hesselbach's triangle and alongside the cord at the internal ring. Hesselbach's triangle can usually be adequately reinforced by overlapping the external oblique fibers over it after reinforcing the transversalis fascia by sliding

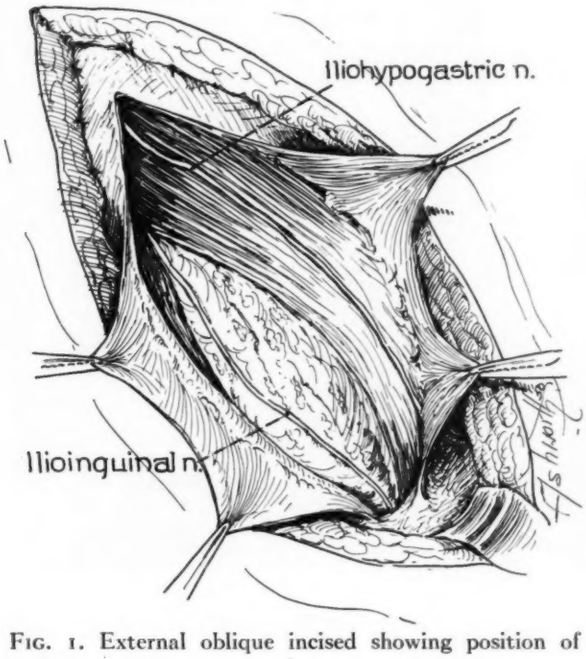
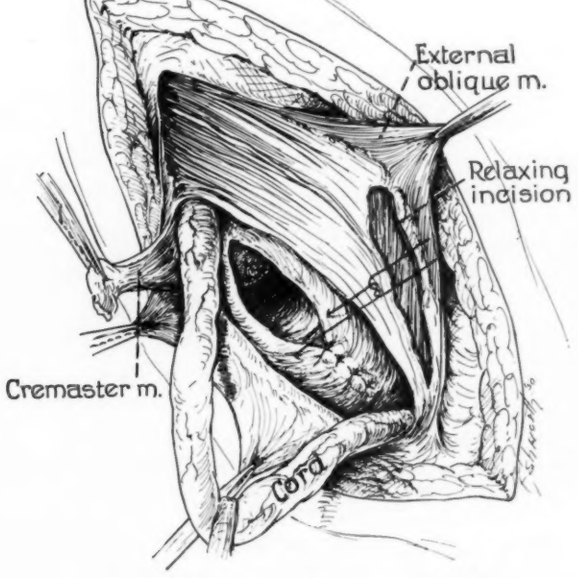


FIG. 1. External oblique incised showing position of nerves.

FIG. 2. Shows the sac isolated from the cord.



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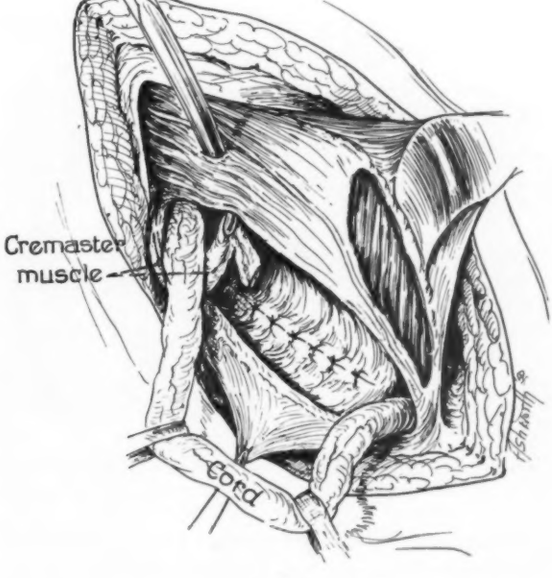

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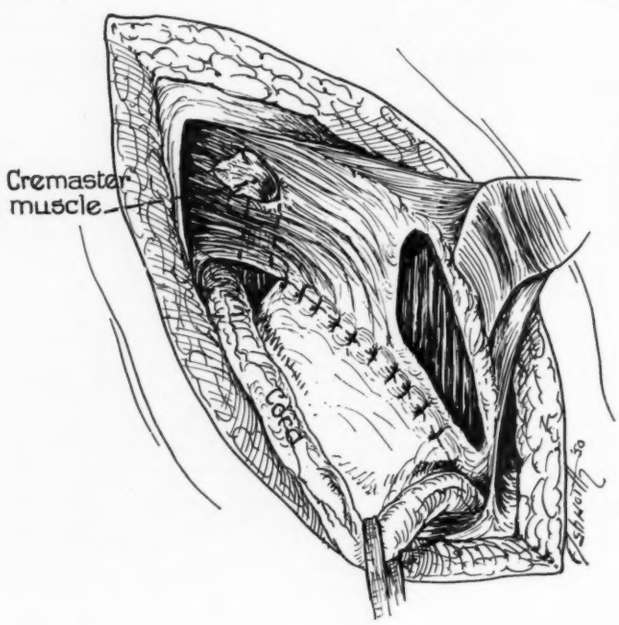
FIG. 3. Cremaster dissected free; relaxing incision made in posterior layer of rectus sheath; first row of sutures in transversalis fascia.

FIG. 4. Cremaster being transferred around cord.

the posterior leaf of the rectus fascia laterally and suturing it to pectineal fascia. This necessitates transplanting the cord to a subcutaneous position and leaves a weak spot where the cord is brought out through the abdominal wall. The weak spot in this area can be satisfactorily guarded only by a tight closure around the cord. This tight closure often leads to swelling of the testicle and a number of suggestions have been made to bring the cord out through a different opening to avoid this complication. It occurred to the author that the cremaster muscle might be used to bolster up this area. As shown in Figures 1 to 8 this maneuver gives a tight washer-like support to the area around the exit of the cord, the washer being composed of living muscular tissue. This technic has been in use since 1946[6] and has satisfactorily lowered the incidence of testicular complications and reduced the number of recurrences.



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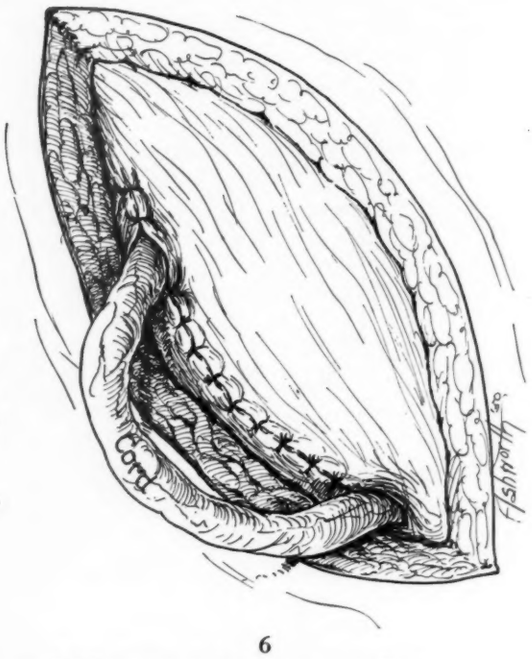

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FIG. 5. Cremaster sutured in place; lateral leaf of external oblique sutured over to rectus fascia.
FIG. 6. Medial leaf of external oblique sutured down over lateral leaf.

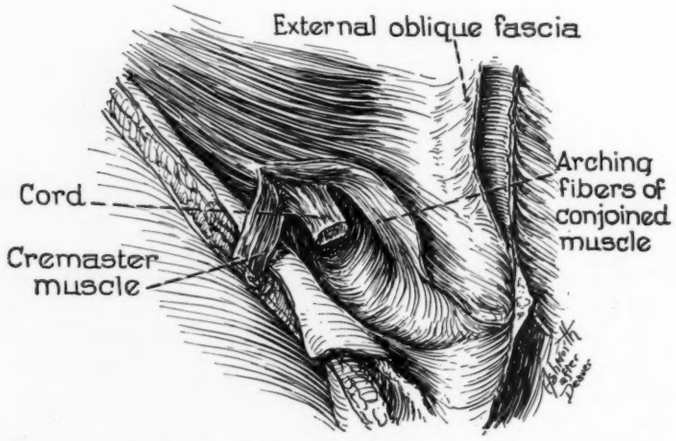

FIG. 7. Anatomy of inguinal region with external oblique removed.

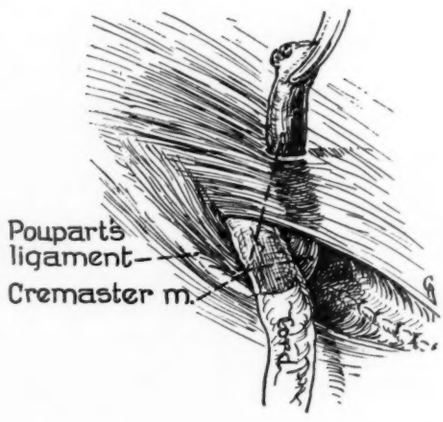

FIG. 8. Detail of new internal ring formed by cremaster.

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A NEW TUBE FOR RAPID EVACUATION OF STOMACH CONTENTS BEFORE ANESTHESIA IN EMERGENCY PROCEDURES

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THE emergency nature of trauma surgery cases inevitably presents the problem of how to avoid aspiration of stomach contents during anesthesia in an unprepared, nonfasting patient. Generally the best method of safely emptying the stomach has been to induce vomiting, either by a to and fro movement of a gastric tube as it is passed through the pharynx or by the administration of apomorphine. However, in many traumatic conditions neither method can be used safely, particularly if there is a possibility of a ruptured liver or spleen.

The accepted procedure with trauma patients has been to insert a stomach tube and evacuate the gastric contents insofar as possible; the results, however, have not been uniformly successful. In a recent study[1] of 300 unselected surgical patients, Culver, Makel and Beecher of Boston have shown that twenty, or 16.1 per cent, of their 124 patients with stomach tubes in place before and during operation regurgitated and seven, or 5.6 per cent, aspirated gastric contents into the lungs during operation. These were prepared patients. Culver states, "aspiration of gastric contents is probably the most serious accident to occur during general anesthesia and surgery. . . . It often is fatal."

This situation has seemed to indicate the need for an improved tube for evacuation of gastric contents. Over a year ago we started working in the laboratory on fresh cadaver human and cow intestines in an effort to develop a more efficient tube for this and other purposes.[2]

In using any of the tubes which have been available heretofore we have been aware that the application of suction to the tube tended to draw the mucosa into the holes of the tube so that drainage was obstructed. We have called this the vacuum mucosal obstruction phenomenon, but had not been aware of how marked it was until we viewed it in our experiments in the autopsy room. It seemed apparent that if this phenomenon could be prevented, a stronger and more constant suction could be used and a more efficient evacuation secured.

In our efforts to overcome this complication we have developed a tube within a tube* which prevents the vacuum mucosa obstruction phenomenon by the application of an air vent. (Fig. 1.) The principle of the air vent can be adapted easily to any of the present single lumen tubes. However, we are currently using for the outer tube a regular stomach tube 3 feet long with approximately thirty holes over the distal 8 inches. Into the outer tube a small diameter polyethylene tube is inserted to within ½ cm. of the distal end. A metal T connector is inserted into the upper end of the outside tube, and the straight limb is closed off by a rubber diaphragm through which a hypodermic needle is inserted to form a tight junction with the polyethylene tube. Suction is then applied to the other branch of the T tube so that the outer tube becomes a suction tube, and the polyethylene tube provides an air vent of atmospheric air at the distal end. The atmospheric air is constantly sucked into the intestine and no vacuum arises. On occasion we have found it desirable to apply the suction to the small diameter tube. This procedure converts the apparatus into an intralumen sump tube which avoids a vacuum and gives constant drainage, but at a slower rate than when the outer tube is used as the suction channel. It also changes the point of maximum suction from the uppermost openings to the end of the tube, a definite advantage.

In the operation of this tube strong suction can be used without danger of injury to the mucosa and, in fact, is necessary for its most efficient use. We find the standard motor suc-

* Manufactured by The George P. Pilling & Son Company, Philadelphia.

FIG. 1. New multipurpose air vent gastrointestinal tube.

tion pump used in operating rooms most satisfactory.

The experimental work was carried out as follows: Fresh calves' stomachs and intestines were obtained from the local slaughter house. A test meal of various foods was mixed with gastric juice removed from patients. This mixture was allowed to stand for two hours and then placed in a calf's stomach. As a control, attempts were made to remove the fluid and gas with available tubes of various sizes and with various amounts of suction. Plain siphonage without any form of continuous suction was the most efficient method in the control group, but even this left much to be desired. Then the air vent or intralumen sump tube was passed into the stomach and the standard operating room motor suction applied. With a minimum of attention, consisting of a few injections of air to unstop the small tube occasionally, the stomach could be emptied completely of liquid and gas, giving it a pancake appearance. We have also noticed this pancake consistency of the stomach when using this tube in gastric and esophegeal resections.

With the walls of the stomach thus pressed together, there is no danger of regurgitation or aspiration. The removal of the larger particles of food is not important since without liquid or air the stomach is not able to expel them. The tube should be left in place during the operation, with continuous strong suction applied.

This tube used for the rapid evacuation of stomach contents is also a great aid in esophageal and gastric resections. The field is kept dry and spillage is prevented during the anastomosis. The same principle has also been used in intestinal obstruction with a long, mercury weighted tube removing as much as 10,200 cc. of brown, obstructed fluid in one twenty-four hour period.

SUMMARY

When confronted with a traumatic injury or any other emergency operative procedure in the unprepared non-fasting patient, this tube with the air vent may be used, completely removing the liquid and air in the stomach. The anesthetist may then proceed to administer the anesthesia of his choice.

This air vent principle is of great value not only in the rapid evacuation of stomach content before anesthesia in emergency procedures but also in aiding esophageal and gastric resections and in decompressing the small bowel in cases of intestinal obstruction.

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PREOPERATIVE PREPARATION OF THE SKIN WITH A DEPILATORY CREAM AND A DETERGENT*

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WHILE reading a magazine last year my attention was drawn to an advertisement of a depilatory cream† which stated that the preparation would remove hair below the surface of the skin. It seemed logical to assume that if the keratolytic agent presumably present in the cream would remove hair below the skin surface, it would also remove the layer of dessicated epithelial cells on the surface. This, it was reasoned, should go a long way toward freeing the skin of surface organisms and detritus. At any rate, the subject seemed worth investigating.

In the past I had remembered complaints about the hydrogen sulfide odor in depilatory powders; also, their use was attended with some skin reactions. It was therefore surprising to find this cream had no obnoxious odor and was not irritating to the skin.

After using several tubes and finding no untoward results I wrote the manufacturers of my experience and inquired if the cream had previously been used in surgery. They had no definite information about this but became interested in the possibility of a new use for the cream. I was then supplied with a half gross of cream in tubes for investigative purposes. Since then additional batches have been used during the past fifteen months. To date 460 patients have been prepared, with no skin reactions.

In the surgery of trauma, encountered in industrial, railroad and automobile accidents, coal dust, grime and asphalt are frequently found forcefully ground into the skin. This has previously required tedious and time-consuming effort in its removal to prevent a discolored scar. In recent months we have found that routine use of the cream removes the major portion of such foreign substances. In such cases the cream is applied before the anesthesia is started. No appreciable tissue reactions have been observed, even in the presence of deeply abraded and oozing surfaces.

In extensive fresh wounds in which large or irregular skin flaps are encountered the wounds are packed off with sterile gauze and the skin areas covered with the cream. This is done just prior to the emergency operative procedure. By the time the patient has been anesthetized and one's hands scrubbed, the cream has done its work. It is then removed with sterile wet gauze. The hair and surface detritus right up to the skin margin of the wound are thus removed more easily and thoroughly than with a razor, soap and water. The cream does not produce irritation to live tissues if some inadvertently gets into an open wound. Saline irrigations may subsequently be used, or not, depending upon the circumstances.

In recent years phisoderm or phiso-hex has been used in the routine hand scrub of the operating team. It has proven much more advantageous than the combination of soap, water, alcohol and some of the numerous mercurial tinctures or other antiseptic preparations. More slowly has been the acceptance of phisoderm for the preparation of the patient. In some hospitals where speed seems to be important operative fields are simply painted with some mercurial preparation with a hideous color. The contained antiseptic usually is colorless but aniline dyes added, for color only, give the erroneous impression of safety in the "paint job." Unfortunately, such perfunctory skin preparation does not suffice in preventing postoperative wound infection. For many years our routine has been a ten-minute scrub with soap and water, followed with alcohol and then the application of one of the mercurials or similar tinctures. Consequently, time has not been an element in changing over to a straight ten-minute scrub with phisoderm instead of the previous regimen. Reduced postoperative infections have been the result.

† Imra Cream (Artra Cosmetics, Inc., Montclair, N. J.)

* From the Department of Surgery, Yale University School of Medicine, New Haven, Conn.

The present preoperative skin preparation combines the use of the depilatory cream and a detergent (phisoderm or phiso-hex). This eliminates the use of razors, soap, alcohol and the usual mercurial or other tinctures.

GENERAL DIRECTIONS

With a wooden tongue depressor use a 2 to 3 mm. thickness of cream in covering the field where hair is to be removed. Work well into the hair follicles with the curved end of the depressor. Leave for fifteen to twenty minutes and wash off with gauze (not cotton) and water of room temperature. The hair and dessicated epithelial cells are removed leaving a clean surface. Where pubic hair is excessive or in animal surgery, the hair may be roughly cut off with a scissors before applying the cream. Less cream is thus used.

More than one patient on the same floor can be prepared simultaneously the day before operation. If the cream stays on a half hour, no harm is done. The nursing and orderly services appreciate such conservation of time.

At the time of operation scrub the operative field with phisoderm, rinsing it off with sterile water from time to time just as in the usual hand scrub. Leave a light film of phisoderm on the surface. No further antiseptics should be used.

In elective joint and tendon surgery the cream will clean the skin better than soap and water, even where appreciable hair is not present. Follow with a five-minute scrub of the field with phisoderm the day or night before operation. Cover the area with a sterile dressing. When the patient arrives in the operating room the next day, the sterile dressing is removed and another five- to ten-minute scrub with phisoderm is done.

When adhesive strapping is to be applied, as in fractured ribs, joint injuries and back complaints, the hair if not coarse is readily removed with cream in six or seven minutes. Tincture of benzoin compound is then applied over the surface. This will insure adherence of the tape and its ready removal when desired.

This depilatory cream is nationally advertised and has been used widely in a cosmetic way. It can be obtained from any pharmacy. Its manufacturers, after prolonged investigation, have found that few people are allergic to the cream.

Because this cream is now classed as a cosmetic, it is subject to 20 per cent luxury tax. Even so, it is not expensive when its merits are considered. Negotiations are now being conducted for the removal of this tax on a new package especially designed for hospital and professional use.

SUMMARY

A depilatory cream without an offensive odor is used for the removal of hair and dessicated epithelial cells. This also eliminates razor cuts. The unusually clean skin is subsequently prepared with a detergent having higher bactericidal properties than the conventional soap and chemical solutions now in general use.

DISCUSSION OF PAPERS BY DRS. NICHOLS, DEVINE AND MORRISON, AND VESTAL

FRANCIS M. THURMON (Boston, Mass.): Doctor Vestal's paper on the depilatory cream, Imra, has considerable merit. The fact that he has successfully prepared 460 patients preoperatively without untoward reactions of the skin is an astoundingly acceptable statement. This surgical experience extending over a fifteen-month period of time is significant.

The use of this cream in traumatic cases to remove foreign material and detritus in addition to hair, and this without apparent injury to denuded tissue, indeed is an added advantage. Certainly, in view of Doctor Vestal's experience and in the matter of a time-saving device as well as efficiency, the technic he describes should be surgically acceptable. It places in the category of antiquity the old procedure of tediously shaving with a razor, soap and water. The importance of avoiding the potential tearing and ripping trauma of hair follicles and skin cuts by a razor in preoperative preparations of open reductions is apparent.

Thus, not only from the surgical angle but also from the dermatologic angle, it was with some interest that the samples of Imra cream which you submitted were received.

Tests with this cream have been confined to its effect as a depilatory agent on various areas of the body surface. These areas have comprised the axillas, leg, thigh, trunk, arm, forearm and pubic regions. The cream effectively removed hair from these areas without a single instance of gross or visible irritation. There has been no subsequent hair follicle plugging, ingrown hairs or irritative papule formation. Regrowth of hair, thus removed, is without incident or complication.

Should the new package designed for hospital use become an eventuality, it would seem that this depilatory and detergent cream should be surgically acceptable.

Caleb Howard Smith (Bradford, Pa.): Having been trained by Dr. J. C. Masson, I have always been interested in and have had respect for hernia repair. It is a truism that one of the principles of hernia repair is the suturing of white tissue to white tissue without having any cover of areolar tissue. I have tried to accomplish what the essayist has accomplished by exposing the fascia of the transversalis and snugging the ring.

But what I really want to say is a word about the use of fascia lata as popularized by Gallie and my chief, Dr. Masson. Very often we see a surgeon repairing a hernia and complaining bitterly that there is not any good tissue; yet there is a lot of good tissue available right down in the thigh but they do not seem to want to use it. I think Dr. Masson's comment on this is the answer: "This method of repair will never be very popular. It is too much work."

The second thing I would like to say has to do with traumatic hernias. Dr. Masson showed me one patient, and from what he said I judged he had several. This man was a Russian, an older man who came from Winnipeg. He had had a traumatic hernia induced to avoid military service in the Russian Army in the first world war. The method of causing this hernia was as follows: The patient was given some pepper in his hand and the operator placed his finger through the external ring and turned it into Hesselbach's triangle. The patient inhaled the pepper; and as he did that, the operator forced his finger through the transversalis fascia. As soon as he inhaled the pepper, the man sneezed and immediately he had a sac.

I have seen this type of traumatic hernia and it is an effective way of making one. Incidentally, as Dr. Masson pointed out, it is quite a difficult hernia to repair.

Gen. Sam F. Seeley (Washington, D. C.): I think we see as many inguinal hernias in military service as in any large industrial group. We operated upon 1,000 patients in San Antonio during my three and a half years there. I have yet to see a case of hernia in which I thought any foreign material was required to accomplish a proper repair.

Dr. Devine's paper emphasizes the necessity of supplying a method by which vacuum can be broken, thus preventing the plugging of a tube when evacuation of the gastric contents is desired.

My greatest concern in the management of perforated ulcer without surgery is plugging of the nasogastric suction tube. We have now had 118 cases of perforated duodenal ulcer. Four patients were admitted moribund; no one would have operated upon them. These patients died. The 114 remaining patients were not operated upon. Only one man died, from coronary occlusion. At autopsy the ulcer was found to be neatly sealed against the liver.

By applying Dr. Devine's principle, if we can be assured that vacuum will be broken and that we can attain continuous, effective gastric decompression, a milestone has been passed.

Laurie H. McKim (Montreal, Canada): Dr. Nichols in his paper on hernia has referred to the function of the cremaster muscle as a material which can be used for repair. This muscle has been so used by a number of people in the past, notably by the late Dr. E. M. Eberts, who was in charge of one of the surgical services in the Montreal General Hospital. In the year 1924 under his direction I operated upon quite a number of hernias. We saw about 300 cases over a period of approximately three years following that time, and Dr. Eberts was particularly interested in why some of the men had recurrences.

He and I very carefully dissected three cases, done by three different men, that had recurred for no obvious reason and we thought we had the answer. When the cremaster was dissected, it was found that it had not been divided at the original operation and it had been left as a nice, large, funnel-shaped opening where the cord came down. It was the easiest thing in the world for a new peritoneal pouch to protrude along this plane.

In each of these cases (two of the three had recurred twice) the cremasteric was carefully dissected and was brought up behind the cord very much as Dr. Nichols has described. In none of the three cases was there any further evidence of recurrence.

Since that time I have carried out this procedure of dissection and the use of the cremasteric muscle as an aid in reinforcing the internal ring in practically every case I have done. I am quite sure that it has reduced the number of recurrences.

Dr. Nichols has referred to the various types of hernias and the question of trauma. I have had the same experience that the previous speaker had with these hernias which were produced by trauma in the old country. I have seen at least twenty or twenty-five of them. Apparently there were men who did a regular job of that kind of thing; in examining men for the Army I found quite a few such cases.

I do not see why a hernia should be considered as due to trauma when it is definitely found at operation that it is of the infantile type, that the peritoneum communicates with the tunica vaginalis; yet I have made reports to insurance companies that such a case was a congenital hernia and the companies go right ahead and pay for that case as a hernia due to trauma. I fail to see why any hernia with a preformed sac which is definitely open should be considered as due to trauma. I am quite willing to admit that many cases possibly are due to traumatic causes, but certainly not those who have a definite preformed sac. I am willing,

however, to admit that such a preformed sac may open and develop into a complete hernia with a minimal degree of strain, even from laughing.

WILLIAM H. CASSEBAUM (New York, N. Y.): I merely want to ask Dr. Vestal how well the cream has worked in those cases in which there is a good deal of scaling of the skin, a thickening such as we find after the removal of a plaster cast that has been on, say, four to six weeks.

I would also like him to tell us what experiences he has had with blondes and redheads.

HENRY C. MARBLE (Boston, Mass.): Some years ago we became interested in the recurrence of hernia and discussed the cause of hernia. Included in our group was Dr. Cotton. After we had spent some hours discussing it, Dr. Cotton settled the whole problem by saying, "I think the time has come when we have to consider that a hernia is part of the overhead." I think that answers one problem. A hernia is part of the overhead and the more we discuss it the less we know about it and get nowhere; so it must be accepted. The main thing is, it must be repaired.

We assembled all of the recurrent hernias that we could find. In the literature the incidence of recurrence has been stated as up to 18 per cent and it has been down, among some of my friends, to nothing. Those fellows who have no recurrences are like various other gentlemen we meet in society who have no infected wounds, who have never left a sponge in the abdomen and that sort of fellow.

Our incidence of recurrence at that time was somewhere in the neighborhood of 6 per cent. We took them apart and analyzed them. The first most frequent form of recurrence found was due to failure of the surgeon to close the neck of the sac adequately and completely. The procedure of ligation and fixation by a simple tie around the neck of the sac was found to be totally inadequate; the neck of the sac must be carefully and meticulously closed with sutures, as any other part of the peritoneum should be closed.

The second most frequent cause of recurrence was the failure of the surgeon to recognize a coexisting hernia. He operated upon an indirect hernia when a direct or femoral hernia was also existing.

The third most common cause of recurrence was the failure to recognize and to appreciate a hernia, a large one, in an old or fat person with soft tissues, and one of those cases about which you have heard the surgeon say when he finishes operating, "I wonder how soon that will come back."

We found and we believed that the cause of recurrence of hernia was the failure of the surgeon to select the proper operation. We then began performing the operation which had been described by McArthur in which we did an ordinary Bassini operation except that we reinforced the Bassini procedure on the lower level with two strips of fascia. As I said, this was described by McArthur many years ago. In fact, he did so before Galli described the use of fascia lata.

The neck of the sac was closed very accurately. We very carefully prepared the cord by resecting the cremaster muscle, leaving only the cord and vital vessels. By so doing we eliminated and reduced the incidence of recurrence in the first two types from somewhere around 6 per cent to approximately 3 per cent.

The third kind of hernia, found in the fat man with soft tissues, the elderly man, presented quite another problem. After some thought we adopted a method, not of castration because we found that that was esthetically undesirable, but of transsection of the cord. In the first few patients treated we found trouble because we transsected the cord too low and had necrosis; we then transsected the cord very high in the region of the internal ring and since that time the incidence of necrosis has been reduced to about 2 per cent. We have seen over fifty of these cases, about sixty, and have had two cases of necrosis of the testicle.

I have never performed the procedure as Dr. Nichols has described it. The only thing he has not told us is his incidence of recurrence, whether it is zero or 18 per cent—and after all, that is the proof of the pudding.

CHARLES G. JOHNSTON (Detroit, Mich.): I am sure that if we took a poll of everyone in this room each person could give a different description of the type of herniorrhaphy he does. I was asked some years ago by a member of this Association what type of herniorrhaphy I used. I told him that until I got through I could not tell him, and then I could not label it; I could only describe it.

I think one of the difficulties in the causes of recurrences is a rigid adherence to a type of hernia repair rather than the utilization of what materials you have. I agree wholeheartedly with Dr. Seeley; I have not yet found a hernia in which I believed that fascia lata needed to be used at all. I agree, also, with Dr. Smith when he says tissue is always available. However, I would add that the tissue is always available directly in that area if one uses it properly and does not have fixed notions about how he must use that tissue but uses surgical principles of not pulling the tissues too tight, of ligating the sac high and supporting the internal ring, and in cases in which there is a direct hernia, of removing the peritoneum as far as possible from the area so that it, too is pulled high and is not redundant.

The question of suction is one, of course, that has been interesting to me for a long time. I think Dr. Devine's paper illustrates a point that has too often been overlooked in the literature regardless of what type of suction, whether gastric or intestinal, that one is using. Most individuals who

are trying to aspirate a stomach will put a great deal of suction on it with the idea that the more suction you use, the better it is going to be. In our clinic we insist on very light suction, for which we use a Stedman pump with our air vent to the outside not to wash air through the stomach but rather to keep the suction low. If the suction is kept low, even though there are food particles there, they will not be drawn tightly into the opening of the tube and one can suck fluid out.

One does not have to go over a rather low pressure to do adequate suction and I am sure these gadgets which are on the market for suction, so-called suction apparatuses, are a definite deterrent.

I could discuss this problem a great deal because I have quite a few pet hates. One of them is the mercury tube. I am sure we are killing a great number of people with these tubes. The mercury tube is an inefficient one; it goes down slowly, and about the only reason I can see for its use would be that the surgeon is too lazy to introduce a proper type of tube into the small intestine.

We do not use, except as a part of our treatment, suction for gastrointestinal perforations of any sort, stomach, duodenum or otherwise; and although I can agree with Dr. Seeley's comments on the first paper, I cannot agree with him on the second, statistics notwithstanding.

H. Minor Nichols (closing): For the sake of brevity I have made few references to the minutia of technic. For example, all the areolar tissue should be removed. This is sliding material which we put around tendons to make them move; however, when you want two tissues to stick together, you should take out the areolar tissue between them.

I like to think of the hernia problem as an equation in which X plus Y plus Z equals the result, X being the surgeon, Y the patient and Z the method of repair. You cannot standardize a method and make every patient fit it. If you have an elderly man with a large defect in the inguinal region, it may be necessary to divide the cord and remove the testicle to prevent a recurrence. If you have an infant or child, it is only necessary to take the sac out. My essay was particularly about the average hernia you encounter in the workman in industry. Here you have to make a good, solid repair. Most of the patients in my series have been of this category.

Coexisting hernias are not at all uncommon in my experience and I make it a rule always to open the peritoneum at the internal ring and feel with my finger inside for a direct or femoral sac. Failure to carry out this maneuver is bound to result in some very unhappy experiences.

As to statistics, I am sure everyone who has tried to follow up patients operated upon five years before have found that a large percentage will not answer follow-up letters. Of the 150 patients seen between 1946 and 1950, of whom a large proportion were steadily employed in municipal or railroad jobs, only about 60 or 70 per cent could be examined. A follow-up of a previous period using the Bassini type of procedure with the Fallis and McVay modifications uncovered about 4 per cent of recurrences. With the new technic the results are much better.

John W. Devine, Jr. (closing): I want to thank Drs. Seeley and Johnston for their discussion. With regard to Dr. Johnston's pet hate about the mercury tube, I just used the mercury-type tube because I thought all night was about long enough to stay up trying to get an air balloon tube through. If we could get them through, I would have no objection to using them. However, the question of the air balloon versus the mercury-tipped tube is not involved here. The contribution which I wish to make is that of the principle of the air vent which can be used any way the operator wishes: with or without the mercury tip or air balloon, with a Miller-Abbott tube or any other.

Paul W. Vestal (closing): I wish to thank the discussers for their helpful suggestions and Dr. Gordon Morrison for his trouble in having a dermatologist recheck the things that we had already done, but it is just additional proof that this cream is not harmful to skins in general.

There are one or two more features that Dr. Cassebaum brought up concerning the use of this cream on skin after a cast has been removed. It is excellent. You can put it on, go away and forget about it, and the orderly or nurse can wash it off later. The physiotherapists like it better because it leaves a perfectly clean skin and they can get at the areas with their massage and baking with more facility.

It takes off not only the dead epithelial cells but also the detritus.

Another thing is that in face injuries, automobile accidents and injuries of that kind, after you have done repair work and the beard grows out, you can hardly see the sutures to take them out. You can use the cream over the sutures. It will not remove the sutures for you but it will take the beard off since it gets down in the grooves and crevices in these irregular wounds and is excellent in that respect.

Blondes and redheads make little difference in the use of the cream because we have never seen any irritation on any type of skin. Eventually someone will probably show an allergic reaction but so far we have seen none.

Occasionally I am asked if I own the company. Unfortunately, I do not own even a share of stock! Medical men are funny that way.

PERFORATIONS OF THE POUCH OF DOUGLAS*

THREE BY IMPALEMENT AND ONE BY SIGMOIDOSCOPY

JOHN H. POWERS, M.D.

Cooperstown, New York

WOUNDS of the perineum and adjacent structures were called to the attention of The American Association for the Surgery of Trauma in Salt Lake City one year ago by Siler and Bebb.[1] These authors described in detail the anatomy of the perineum in both sexes, discussed types of injury in relation to the anatomic structures involved, and emphasized some of the important principles underlying the care of such wounds. Two cases of perforation of the rectum and bladder were reported, one by impalement on a corn stalk and one in which perforation of the rectovaginal septum followed the administration of daily enemas.

The purpose of this communication is to record four cases of perforation of the pouch of Douglas, three by impalement and one by sigmoidoscopy. The first case was published by Powers and O'Meara in 1939;[2] the other three have not previously been reported.

CASE REPORTS

CASE I.[2] P. U., a male aged eighteen years, while doing kitchen duty in a C.C.C. Camp, slipped on the wet top of a table on which he was standing and fell on the upright handle of a mop. The blunt end of the implement penetrated a pair of duck pants and heavy winter underwear, and entered the rectum for a distance of 8 inches. (Fig. 1.) The boy, thus impaled, removed the mop handle himself, felt no immediate pain, but was conscious of a desire to defecate and passed a small amount of fresh blood. Twenty minutes later he began to suffer low abdominal pain and examination by a local physician within an hour disclosed generalized abdominal spasm. He was admitted to The Mary Imogene Bassett Hospital three hours after the accident occurred.

Physical examination at that time disclosed generalized abdominal tenderness, most intense below the umbilicus, and board-like rigidity of the entire abdominal wall. There was a small, irregular laceration of the perineum extending into the anterior margin of the anus; no rupture of the rectal wall could be felt.

The oral temperature was 100°F., pulse 58, respirations 22, blood pressure 128 systolic, 96 diastolic. The hemoglobin and erythrocytic count were a little above normal; leukocytes were 18,500 with 85 per cent polymorphonuclear neutrophiles. The centrifuged sediment from a specimen of clear urine obtained by catheter was normal except for 4 to 8 erythrocytes per high power field.

The tentative diagnoses were puncture wound of the perineum by impalement, perforation of the rectum and generalized peritonitis.

Operation was performed through a midline, suprapubic incision. Liquid and solid fecal material was disseminated throughout the peritoneal cavity as visualized. An irregular perforation about 2.5 cm. in diameter was found in the peritoneum of the pouch of Douglas and below this a rupture of corresponding size in the anterior wall of the rectum.

The edges of the rectal wound were approximated in two layers, the rent in the pouch of Douglas was closed and one cigarette drain was placed in each side of the pelvis. A loop of sigmoid was brought out through a second short incision over the left rectus muscle, the midline incision closed and a sigmoidostomy established immediately.

The convalescence was complicated by early clinical and roentgenologic evidence of pneumonia in the right lower lobe, followed by serum sickness subsequent to the injection of polyvalent serum against gas-forming anerobes. After closure of the sigmoidostomy, the intestinal tract functioned normally. Both abdominal wounds healed kindly. The patient was seen occasionally during the next two years and remained free from symptoms referable to the gastrointestinal tract or colon.

CASE II. E. L., a female twenty-seven years of age, was skiing down a narrow trail through the woods when she lost control and ran off the trail in order to stop. In falling she either sat down upon or slid against a stick projecting above the snow, for she felt immediate pain in the perineum and across the lower abdomen. When examined by her female companion, a branch was seen protruding from the seat of her ski pants, so firmly embedded in the rectum and perineum that the strength of a man, who came down the trail soon after the accident occurred, was required to withdraw it. When found by a member of the ski patrol shortly thereafter,

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the patient was lying 15 feet off the trail on her back with her knees drawn up, obviously seriously injured. She was taken down the trail on a toboggan, the toboggan and patient transferred to a station wagon, and brought to the Hospital without delay.

When examined in Minor Surgery one-half hour after the accident, the patient was not found to be in shock. She complained of generalized abdominal pain, most intense in the left lower quadrant. Marked tenderness was present in this area with slight tenderness throughout the abdomen. There was no spasm. The wound in the perineum was dirty and ragged, extended through both anal sphincters, and the anterior wall of the rectum.

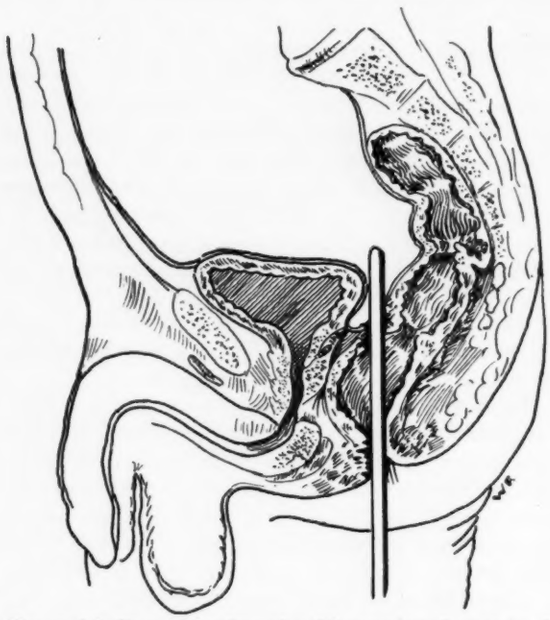

FIG. 1. Median sagittal section illustrating the path of the mop handle through the perineum, anterior rectal wall, and pouch of Douglas into the peritoneal cavity. (From POWERS, J. H. and O'MEARA, E. S. *Ann. Surg.*, 109: 468–473, 1939.)

During the next hour the abdominal pain increased, diffuse tenderness became more marked, and spasm developed in the left lower quadrant. A specimen of urine obtained by catheter was grossly clear and contained no microscopic blood.

The oral temperature was 99.2°F., the pulse 100, respirations 20 and blood pressure 120/80. The hemoglobin was 12.5 gm., the erythrocytic count 4,200,000, the white blood count 20,300 with 91 per cent polymorphonuclear neutrophiles.

The tentative diagnoses were puncture wound of the perineum by impalement, laceration of the anal sphincters, perforation of the rectum and pouch of Douglas, and peritonitis.

Operation was performed through a midline suprapubic incision. Blood was disseminated throughout the peritoneal cavity. From the pelvis many large fragments of bark were removed which had separated from the wood as the stick was withdrawn. (Fig. 2.) Deep in the pouch of Douglas was a large perforation in the peritoneal reflection just to the left of the midline and below this a rent in the anterior wall of the rectum which could be visualized only with the aid of the operator's left index finger introduced through the anus from below. Thereafter the edges of the rectal defect were identified and approximated and the rent in the pouch of Douglas was closed. A large tear in the mesentery of the small intestine, the source of the intraperitoneal blood, was sutured. Ten grams of buffered sulfanilamide were placed in the pelvis and the abdominal wall was closed in layers with silk.

The patient was then placed in lithotomy position and the perineal area prepared and draped for operation. The cutaneous edges of the perineal wound were excised, the devitalized portion of the sphincteric muscles was cut away and the sphincters were sutured; 5 gm. of sulfanilamide were placed in the wound, and the edges were approximated without drainage.

On the first postoperative day the patient received tetanus antitoxin and polyvalent serum in divided doses. Chemotherapeutic agents and fluids were administered parenterally until the fifth day; thereafter, sulfanilamide was discontinued and fluids, solid food and mineral oil were allowed by mouth. A rectal tube placed at operation was removed on the sixth day; subsequently the patient had occasional incontinence of flatus but normal control of stools.

The abdominal wound healed per primam; some cellulitis about the perineal wound responded to the local application of heat and this area likewise healed satisfactorily.

During the next eight months the anal sphincters were digitally dilated at intervals; the function of the gastrointestinal tract was normal. The patient was accepted by the Navy the following year; later she married and a recent note, nine years after the accident, states that she has had two children and considers herself entirely well.

CASE III. W. C., a boy aged seventeen years, while putting hay into his uncle's barn, left his pitchfork standing upright in the load while he climbed the mechanical loader to make some adjustment in the machinery. In getting off he jumped backward directly onto the handle of the pitchfork which penetrated his clothes and entered his rectum for a distance of "5–8 inches." He felt immediate abdominal pain, became faint, and vomited, but soon recovered sufficiently to walk to an automobile for transportation to the office of a local physician. The doctor did a rectal examination, catheterized the boy, gave him a soapsuds enema and sent him home.

FIG. 2. Fragments of bark removed from the pelvic peritoneal cavity of the patient described in Case II.

Because of increasing abdominal pain, persistent vomiting and the passage of several watery stools containing fresh blood, the local doctor was again consulted and advised the administration of another enema. Abdominal pain became more severe, the temperature rose gradually to 104°F., and the patient was brought to the hospital ten hours after the accident occurred.

Examination disclosed generalized spasm of the abdominal wall most intense in the lower quadrants, exquisite direct and rebound tenderness across the lower abdomen, moderate in the epigastric area and hypochondria. The perineum was contused, the anal sphincter relaxed; 2–3 cm. above the prostate the examining finger encountered "a shelving tear" in the anterior wall of the rectum which was not investigated further before operation.

The oral temperature was 100.4°F., the pulse rate 104 and respiratory rate 29; the blood pressure was 94 systolic, 60 diastolic. The hemoglobin was 14 gm., the leukocytic count 5,600 with 74 per cent neutrophiles, and the urine was normal.

The diagnosis was perforation of the rectum by impalement with diffusing peritonitis.

Operation was performed through a low left rectus incision. Upon opening the peritoneum there was an immediate puff of gas followed by a gush of moderately thick grayish pus without odor. The amount of pus increased as the pelvis was approached and particles of fecal material were present there. A perforation was found in the pouch of Douglas which was continuous below with a tangential tear through the anterior wall of the rectal ampulla and above with a superficial laceration of the postero-inferior wall of the bladder.

Traction sutures were placed at each end of the laceration and the muscular margins of the rectum were closed in two layers, the more superficial of which included the peritoneum of the pouch of Douglas and the posterior vesical wall. Gross contamination was removed from the pelvis, buffered sulfanilamide was dusted into the abdominal wound and the incision sutured in layers with catgut and silver wire. No drains were used.

Immediately after operation the bladder was placed on constant drainage through an inlying urethral catheter. The patient was given 3,000 units of tetanus antitoxin and 26,000 units of polyvalent serum. A low-grade infection of the abdominal wound, apparent on the sixth day, was drained adequately by separating the edges of the skin between two stay sutures of silver wire. A "boggy mass of indurated, edematous mucosa" at the site of the rectal wound disappeared spontaneously and the patient was discharged on a regular diet with mineral oil nineteen days after operation. The sphincteric control of both bladder and rectum was normal.

He was seen at intervals during the next three years and had no symptoms referable to the gastrointestinal tract.

CASE IV. W. O., a farmer fifty-two years of age, entered the Hospital for hemorrhoidectomy. He had had "itching piles" for twenty years with occasional protrusion, burning and pain after defecation.

The physical examination was normal except for internal hemorrhoids and a few small external condylomas.

Operation was performed under spinal anesthesia by one of the surgical interns with the assistance of the resident surgeon. Hemorrhoidectomy was preceded by proctoscopy. The note states: "The proctoscope was passed for its full length; no abnormalities of the rectum or sigmoid were seen."

The patient was placed on the usual post-hemorrhoidectomy regimen of clear fluids only and deodorized tincture of opium three times daily for

four days. He was up and about the ward, apparently convalescing normally. On the evening of the third postoperative day a retention enema of 100 cc. of oil was administered through a small soft rubber catheter passed 4 inches into the rectum. Thereafter he was aware of tenderness at the anal orifice but slept well following the administration of morphine.

The following morning he complained of abdominal pain. Examination disclosed generalized abdominal tenderness but no spasm and no rectal tenderness. The temperature was 98.6°F. and the pulse rate 82. A soap-suds enema was given which the patient failed to expel. Thereafter the intensity of the abdominal pain and tenderness increased rapidly. Generalized rigidity of the abdominal wall developed. Rectal examination then revealed acute pelvic tenderness; no defect in the rectal wall was felt. The leukocytic count rose to 19,800 with 96 per cent polymorphonuclear neutrophiles. Roentgenogram of the abdomen with the patient erect revealed a large collection of free air beneath each leaf of the diaphragm. It was then apparent that the diagnosis was perforation of an air-containing viscus with generalized peritonitis; the site of perforation was not suspected.

Operation was performed through a right midrectus incision. Diffusing peritonitis was present. Much purulent material welled up from the pelvis; the entire sigmoid and pelvic peritoneum were covered with large thin sheets of fibrin. Accordingly, the incision was enlarged distalward, the general peritoneal cavity packed off with pads moistened in warm saline solution, and a large rent discovered in the anterior wall of the sigmoid at the level of the sacral promontory. The perforation was transverse in direction and measured 3 to 4 cm. in length; the mucosal edges were pouting through the hiatus. These were closed with a running stitch of No. 00 chromic catgut; a second suture of the same material was placed through all layers of the sigmoid except mucosa; the area was then inverted with mattress sutures of silk. Five grams of sulfanilamide and 50,000 units of penicillin were left in the pouch of Douglas.

A short oblique incision was made in the right lower quadrant and a portion of the cecum delivered through the abdominal wall. The omentum was then interposed between the coils of small intestine and the pelvic cavity and the operative incision closed in layers with silk and stay sutures of heavy deknatel. An immediate cecostomy was established using a Paul tube.

The postoperative course was very benign. Constant gastric suction was established through a Miller-Abbott tube, the tip of which was allowed to remain in the stomach. There was very little drainage through the cecostomy and no abdominal distention. The patient's bowels moved normally on the fourth day and daily thereafter. A soft diet was then allowed and a regular diet with mineral oil four days later. The abdominal wound healed kindly with minimal reaction about the retention sutures. The cecostomy was closed on the seventeenth postoperative day.

Five years later he was readmitted to the Hospital for repair of bilateral inguinal hernias. During the interim he had been free from symptoms referable to the gastrointestinal tract. Both abdominal wounds were firmly healed and rectal examination was normal.

Remarks. Prior to hemorrhoidectomy this patient was sigmoidoscoped, while under anesthesia, by a junior member of the surgical house staff. No mishap or abnormality in the examination was reported. During the first three postoperative days only clear fluids and deodorized tincture of opium were allowed. Subsequent to the administration through a soft rubber catheter of oil retention and soapsuds enemas on the evening of the third and morning of the fourth days, he developed signs of fulminating peritonitis. At operation the rent in the anterior wall of the rectum and pouch of Douglas was found to be above the level to which the tip of the catheter had been introduced; furthermore, it was of proper size to have been caused by the advancing end of the sigmoidoscope. It was therefore concluded that perforation had occurred when sigmoidoscopy was performed, that the inactivity of the colon during the first three postoperative days had allowed the wound to close temporarily, possibly with a plug of omentum, and that dissemination of infection to the general peritoneal cavity did not occur until administration of the enemas disrupted the temporary seal.

COMMENTS

Perforations of the pouch of Douglas by impalement, sigmoidoscopy and the insertion of hard rubber nozzles or even soft tubes for the administration of enemas are being reported with increasing frequency.[1,3,4] Wounds of the rectum and sigmoid due to missiles of high velocity were common during the last war and have likewise often been recorded.[4] Consequently, no general discussion of the subject will be presented in this report. The author wishes only to comment on certain controversial points which are of interest in both diagnosis and treatment.

Preoperative Proctoscopic Examination. An inquiry regarding the depth to which the object penetrated, an attempt to visualize the direction of the impact and a careful digital examination of the rectum are all of value in establishing an accurate diagnosis. However, such examina-

tion may be misleading if the wound in the rectal wall is beyond reach of the examining finger. For this reason Jackman[5] believes that proctoscopic examination "may be a life-saving measure" in establishing a prompt diagnosis and early definitive surgery. He further advocates the insertion of a catheter through the rent in the rectal wall to assist the surgeon in locating the lesion at laparotomy. It is the opinion of the writer that proctoscopy may be of value in certain patients seen promptly after injury when doubt exists regarding the continuity of the rectal wall. However, the early abdominal signs of peritoneal irritation due to infection or hemorrhage, or both, should lead to the diagnosis of perforation of the rectum through the pouch of Douglas without the additional hazards incidental to the passage of a sigmoidoscope.

Preoperative Cystoscopy. Knowledge of whether or not the bladder was full at the time of the accident, whether or not the patient voided during the interval between the accident and the examination, and whether he passed blood by urethra or urine by rectum or through the perineal wound is very helpful. The same is true of blood or urine from the vagina in the female. Every patient with an impalement-injury of the external genitalia, perineum, anus or rectum should be catheterized rather than urged to void spontaneously. If a catheter can be passed, there is no necessity for cystoscopy. The integrity of the vesical wall, if in doubt, may be more simply and safely determined by cystography after the injection of diodrast through the catheter. If bloody urine or gross blood has been voided and a catheter cannot be passed, suprapubic exploration and drainage of the bladder are imperative when the rectal perforation is repaired.

Operative Colostomy or "Precolostomy." Reference to many of the articles on war wounds of the colon and rectum in the aforementioned bibliographies indicates that exteriorization of a perforated wound of the colon or colostomy proximal to a wound of the rectum was invariably effective in reducing the mortality from such injuries in military surgery. Operative treatment was often carried out in forward installations from which the patients were evacuated within a few days and colostomy under those circumstances was a very real safeguard.

The situation is by no means comparable in civil surgery. The civilian patient usually has no complicating extensive injuries of bones and soft tissues, his general health has not been previously impaired by constant exposure to the elements with inadequate food and rest, and he is in a stable surgical environment where he may be constantly under the care of one surgeon or one surgical service. The use of gastric suction through a Miller-Abbott tube with the tip in the stomach to prevent gastrointestinal distention due to swallowed air, the advancement of the tube into the small intestinal tract if distention does occur, manual dilatation of the anal sphincters after operation, and the use of an inlying rectal tube with the tip 4 or 5 inches above the sutured rectal wound will often obviate the necessity for establishing a proximal colostomy in civil surgery.

Local Use of Chemotherapeutic Agents and Antibiotics. The first three patients in the small group herein described were operated on before penicillin was readily available and during the period of enthusiasm for the local use of one or the other of the sulfonamides for the control of infection in traumatic wounds and in peritonitis. These have now largely been abandoned in favor of the oral or parental use of one or more antibiotics specific against the invading organism or organisms. However, the local use of both penicillin and streptomycin in the pelvis following suture of a perforated wound of the rectum and pouch of Douglas is by no means contraindicated and may be of value in exposing the peritoneal infection to a high concentration of these agents during the immediate postoperative period.

Treatment of the Perineal Wound. Difference of opinion exists regarding treatment of the local perineal wound. Some authors, notably those with military experience,[4] advise extensive débridement, removal of all foreign material, accurate hemostasis, free drainage of the retroperitoneal space and preservation of the anal sphincters whenever possible. Others suggest the use of tampons to control bleeding and afford drainage.

In civilian surgery equally extensive débridement and meticulous hemostasis are likewise essential; thereafter the wound may be closed with a reasonable expectation of primary healing if antibiotics be used liberally during the early postoperative period.

SUMMARY

Four patients with perforated wounds of the pouch of Douglas, three by impalement and one by sigmoidoscopy, have been reported; all recovered.

The value of preoperative proctoscopy and cystoscopy as diagnostic aids, the desirability of performing colostomy or "precolostomy" after closure of the pouch of Douglas, the local use of chemotherapeutic agents and antibiotics in the pelvis and the correct treatment of the perineal wound have been discussed.

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TRAUMATIC PANCREATITIS WITH AND WITHOUT ASSOCIATED INJURIES*

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DURING the years 1942 through 1950, 171 patients were admitted to the San Francisco Hospital who, on the basis of serum amylase studies, operation or autopsy, proved to be suffering from acute pancreatitis. During the same period pancreatitis due to injury was encountered in seventeen patients. Nine were due to blunt injuries to the abdomen and eight due to penetrating injuries (gunshot wounds and stab wounds).

Many authors[1–3] have emphasized the fact that the pancreas because of its deep situation within the abdomen is well protected from injury. For this reason it is rare for a blunt blow upon the abdomen to cause injury to the pancreas alone. Although such injuries do occur, they are reported to be exceedingly rare.

Our study would indicate that traumatic pancreatitis is more common than generally recognized. It is true that the anatomic situation of the pancreas, deeply seated within the abdomen, tends to protect it, particularly from blunt injury. However, direct blows to the abdominal wall, particularly when the abdomen is flexed, may impinge the body of the pancreas between the solid vertebrae behind and the striking force on the anterior abdominal wall. If the striking instrument is semi-sharp, such as a policeman's club or the handlebar of a bicycle, the blow may be a localized one causing injury to the pancreas alone whereas more gross instruments, such as the fender of an automobile, are apt to include other viscera, causing associated injury to the liver, spleen, bowel or kidney.

We were interested to note in our studies that in five of the nine patients with pancreatitis caused by blunt, non-penetrating injuries to the abdomen the pancreas was the only organ involved. In each of these five, as far as we could determine from the mechanism of injury, the patient was struck in the mid-abdomen with a semi-sharp instrument. One patient was struck with the headlight of an automobile, one with a policeman's club, one with the handlebar of a motorcycle, one while playing volleyball and one was kicked in the region of an umbilical hernia. The remaining four patients in addition to injury to the pancreas had associated injuries to the spleen duodenum, stomach or liver. All of the latter four were involved in accidents of severe violence; three were struck by automobiles and one patient fell from a fourth story window. These four patients presented not only evidence of intra-abdominal injury but also were suffering with injuries to the chest wall or extremities as well. The significance of these associated injuries, remote from the abdomen, will be commented upon later.

Penetrating wounds of the abdomen rarely cause injury to the pancreas alone. Here again the anatomic position of the pancreas almost completely excludes it from injury unless one of the surrounding viscera is perforated. Eight of our patients were suffering with penetrating wounds, namely, five gunshot wounds and three stab wounds. In one of the stab wounds the stomach and pancreas were involved, in one the spleen and tail of the pancreas, and in one the stomach, small bowel, liver, kidney and pancreas were injured.

As one might expect, penetrating wounds caused by gunshot are usually more extensive than those caused by stab wounds. In the five patients with gunshot wounds of the pancreas the stomach also was perforated in three, and in addition there were injuries to the kidney in one, the liver and vena cava in one, the common bile duct in one and the lung in another. These associated injuries not only add to the difficulties in diagnosis but also, depending upon their severity, alter the prognosis considerably.

The clinical signs and symptoms associated with traumatic pancreatitis are dependent

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first upon the type and extent of injury to the pancreas and secondly upon the associated injuries.

Mild trauma to the pancreas alone, causing simple edema or small hemorrhages into the gland, we assume may cause little or no signs and symptoms. These patients probably do not seek medical care and for this reason go unrecognized. Unless such a patient were explored by laparotomy for other reasons, the diagnosis would remain obscure.

Injuries sufficient to cause extensive hemorrhage into the gland do cause abdominal pain, usually associated with vomiting. Generalized abdominal tenderness, more marked in the epigastrium, was present in our patients. Audible peristalsis was reduced. Mild fever and leukocytosis also were present. The most helpful adjunct to diagnosis in this group of patients, as pointed out by Naffziger and McCorkle,[4] is the serum amylase determination. An immediate rise in serum amylase may be the only positive sign of pancreatic disease.

Rupture of the pancreas with extravasation of pancreatic enzymes causes more severe signs and symptoms. Abdominal pain radiating to the back or shoulder is usually severe and signs of moderate or severe circulatory collapse may develop. An elevated serum amylase serves to focus one's attentions on the pancreas.

Often, as in the usual forms of pancreatitis, the signs and symptoms are so variable and inconstant it is impossible to make the diagnosis on clinical criteria alone.

It has been our experience that symptomatology referable to other intra-abdominal injuries usually overshadows that due to injury to the pancreas. Hemorrhage from a ruptured spleen or liver or peritonitis from lacerations of the stomach or small bowel causes more alarming symptoms than does the usual injury to the pancreas alone. However, flooding of the lesser sac with pancreatic juice from a laceration or rupture of the pancreas may lead to the typical alarming picture of acute hemorrhagic pancreatitis. Delayed rupture of the pancreas, caused by digestion following hemorrhage, may lead to pseudocyst formation but in our experience usually is not accompanied with the sudden severe reaction seen with a primary laceration.

Symptomatology referable to an abdominal injury may be completely obscured in the beginning by other associated injuries, particularly those to the head and extremities. The obvious evidence of injury under these circumstances may focus one's attention elsewhere than the abdomen. For this reason careful attention should be focused upon the abdomen in all injuries of severe violence regardless of the initial symptomatology. Repeated careful examinations may be necessary to reveal signs of serious intra-abdominal pathology unsuspected at the original examination. Serum amylase studies should be undertaken at once.

Two of our patients, both suffering with compound fractures of the femur, were treated for these injuries while little attention was paid to abdominal complaints which seemed unimportant at the time. The signs and symptoms of intraabdominal injury, which were mild in the beginning, gradually became distressing. Elevated serum amylase determinations focused our attention on the pancreas. In both of these patients pseudocysts of the pancreas developed.

Pseudocysts are known to result from injury to the pancreas as well as from pancreatitis of other origin. Pinkham,[5] who reported a series of pancreatic pseudocysts from our clinic in 1945, believes that trauma is responsible for 20 per cent or less of the cases. At times we have found it extremely difficult to determine the possible relationship of trauma to the abdomen and the development of pseudocysts. This is true particularly when a patient presents himself with symptoms referable to a pseudocyst rather than to the original trauma. Unless one can definitely establish the history of injury followed by signs and symptoms of pancreatitis, the etiologic relationship may never be known inasmuch as pseudocyst formation may occur weeks or months subsequent to the original trauma. One of our patients in whom a diagnosis of traumatic pancreatitis was made on the basis of clinical signs and a prolonged elevation of serum amylase following abdominal trauma returned to the hospital two years subsequent to the original injury suffering from a pseudocyst of the pancreas. Had he not been under our observation originally and had we not had the serum amylase determination, the interval history would have suggested chronic recurring pancreatitis. The original trauma in this case we believe was the precipitating cause of his subsequent illness.

For obvious reasons it is important from a

medicolegal point of view to establish the etiologic relationship between abdominal trauma and the development of a pseudocyst of the pancreas. It is therefore important that immediate and repeated serum amylase determinations be undertaken in all patients with abdominal injury. The history of abdominal injury associated with a recorded elevation of serum amylase in a patient in whom pseudocyst of the pancreas subsequently develops is definitely more reliable from the point of view of etiology than the history of injury alone. The history of an unrecorded abdominal injury, although often easily obtained (particularly from the chronic alcoholic), should be considered with skepticism. One of our patients who dated his symptomatology from a kick in the abdomen by a horse gave a long history consistent with the diagnosis of recurrent pancreatitis. Physical and x-ray examination demonstrated a mass in the epigastrium displacing the stomach anteriorly. A preoperative diagnosis of pancreatic pseudocyst was made. Operation proved the mass to be an aortic aneurysm.

It has been emphasized by Shallow[6] that the serum amylase test and the trend toward conservative management of acute pancreatitis represent the two recent advances which have widened the recognition of this disease, rendered its diagnosis more certain and greatly reduced its mortality.

We agree, as advocated by Shallow, that the same non-operative management of pancreatitis following non-penetrating abdominal trauma be undertaken as that advocated from the more common forms of pancreatitis provided, of course, that associated injuries to other abdominal viscera or blood vessels can be ruled out. If clinical improvement occurs and persists on conservative management with nasal suction, intravenous fluids and antibiotics, as one expects in the usual type of pancreatitis, conservative management is justified. Little is to be gained by exploratory laparotomy if contusion with hemorrhage in the pancreas is the only pathologic condition. However, if the patient's condition does not improve under conservative management or if one is suspicious of gross hemorrhage or peritonitis, early surgical intervention is indicated. Lacerations of the pancreas when encountered should be sutured. It is accepted surgical practice to drain the lesser sac in those cases in which a contused laceration does not lend itself to suture or when fluid is found accumulated in the lesser sac. The prognosis under these circumstances in our experience is not good. Spreading pancreatic necrosis with peritonitis and abscess formation are not infrequent sequelae.

The management of pseudocysts has become a controversial problem. The time-honored method of treatment has been marsupialization of the cyst when possible. Extirpation of the cyst wall and internal drainage also have been advocated. The latter two methods of treatment are indicated when the position and size of the cyst do not permit marsupialization.

SUMMARY AND CONCLUSIONS

1. Traumatic pancreatitis is more common than generally recognized. Seventeen of 171 cases of pancreatitis studied at the San Francisco City and County Hospital were traumatic in origin.

2. Blunt, non-penetrating injuries to the abdomen may cause injury to the pancreas alone. Five of the nine patients suffering with pancreatitis as the result of non-penetrating abdominal injuries had no other associated intra-abdominal pathologic disorder.

3. Penetrating wounds of the abdomen rarely cause injury to the pancreas alone. All of the eight patients suffering with penetrating wounds of the pancreas had associated injuries to other abdominal organs.

4. For medicolegal as well as clinical reasons serum amylase studies should be undertaken in all patients with abdominal trauma.

5. The conservative management of pancreatitis of traumatic origin is indicated only when the suspicion of associated injuries to other abdominal organs can be eliminated.

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SUBPHRENIC ABSCESS IN TRAUMA*

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THIS study of subphrenic abscess was undertaken because of our interest in the occurrence of this condition in connection with abdominal trauma and a concern with our difficulties in diagnosis and treatment. In recent years we have thought the pre- and post-operative course of this disease had become somewhat less stormy, which might warrant an altered outlook as to prognosis, but this study does not support that contention.

TABLE I
MATERIAL ANALYZED

Average age: 47 years
Spread: 9 to 68 years
Males: 33
Females: 6

Right		Left
20		15
4	Bilateral	4
24		19

The material which we have studied consists of the case records of thirty-nine patients who had forty-three subphrenic abscesses. We have excluded from our study those cases following liver abscess. (Table I.) The incidence of this condition in the male is five times that of the female, which has been noted by Delario[1] as being four to one. The incidence of location of the abscess, as to right or left, is almost the same. Harley's[2] incidence is 65 per cent right, 27½ per cent left and 5 per cent bilateral in 182 cases.

Table II compares the etiologic factors in our series with the Ochsner and DeBakey[3] data from their review of the world literature and the Whipple[4] figures published in 1926. The only factors of significance are the relative unimportance in our series of the appendix, and the nine abscesses following abdominal trauma. The world literature, as studied by Ochsner, lists only seventy-four cases due to trauma for an incidence of 2.2 per cent as compared with our incidence of 23 per cent. In one case the etiologic factor could not be established.

Approximately 75 per cent of our cases followed introduction of bacteria with perforation of a ruptured hollow viscus, whereas the remaining followed a surgical procedure done in a clean abdomen. The four gastrectomies with this complication had leakage of a suture line.

TABLE II
ETIOLOGY

	No. of Cases
Authors' Series (1951)	
Perforated ulcer	12
Abdominal trauma	9
Biliary tract	6
Gastric surgery	4
Splenectomy (elective)	2
Perforated carcinomatous colon	2
Ruptured appendix	2
Nephrostomy	1
Unknown	1
Total	39
	Per cent
Ochsner (1933, world literature 3,322 cases)	
Appendix	30.7
Stomach and duodenum	29.0
Liver and bile passages	12.0
Spleen	4.0
Kidney	3.3
Trauma	2.2
	Per cent
Whipple (1926, 1,000 cases)	
Lesions of stomach	25
Appendix	21
Biliary tract	16
Duodenum	5

Table III consists of a breakdown of the trauma cases. In three of the nine cases there was no contamination of the peritoneal cavity by perforating injury to the gastrointestinal tract. The abscesses followed injury to the liver and spleen with intra-abdominal hemorrhage.

TABLE III
ABDOMINAL TRAUMA

Gunshot wound of abdomen	3
Stab wound of abdomen	2
Fractured liver	2
Fractured spleen	1
Bougie perforation, stomach	1
Total	9

* From the Department of Surgery, Wayne University College of Medicine, and the Detroit Receiving Hospital, Detroit, Mich., and Veterans Administration Hospital, Dearborn, Mich.

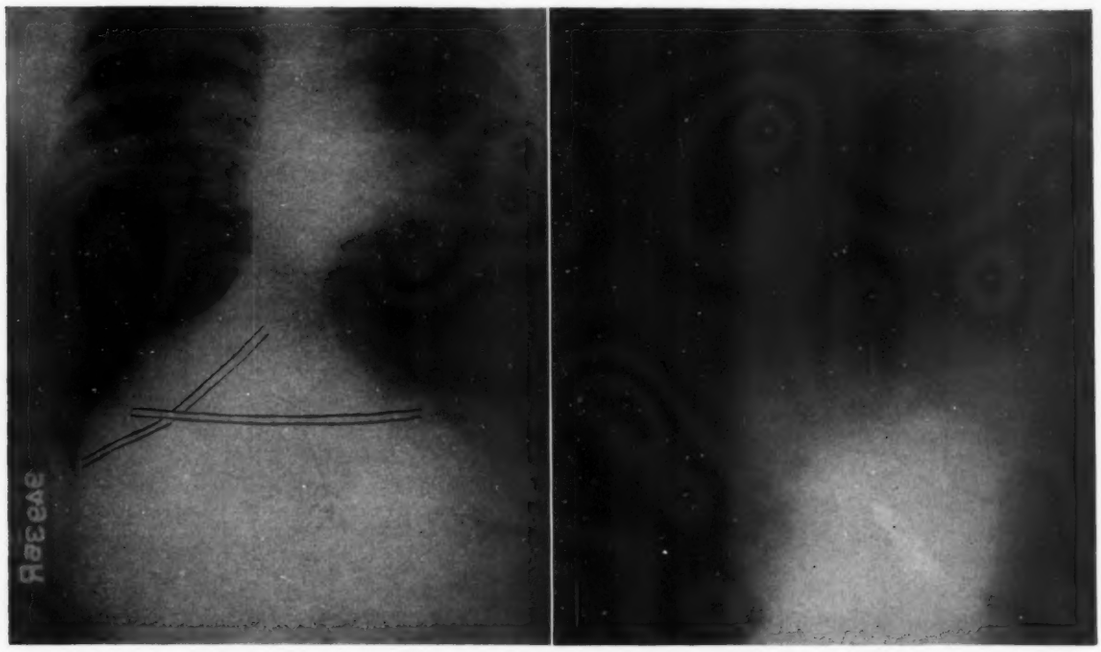

FIG. 1. Anteroposterior and lateral views of an induced pneumoperitoneum demonstrating the potential space beneath the diaphragm, some portion of which becomes occupied by subphrenic abscess. The double lines indicate the location of the anterior costal margin and the first lumbar spinous process.

In the last instance, that of bougie perforation of the stomach, the surgeon was the offending agent.

Abscess content was cultured and reports are available on twenty-four of the operated cases. In three cases the culture was reported to be negative. In the positive cultures, a mixture of organisms was found in all except one, a pure culture of Friedländer's bacillus type A being reported. Escherichia coli was detected in 45 per cent of the abscesses cultured, and next in order of frequency were streptococcus, Bacillus, proteus, diphtheroids, pseudomonas, staphylococcus, and Aerobacter aeroginosa. All the patients received antibiotics (principally penicillin and streptomycin) prior to surgical drainage.

The abscesses on which we are reporting were all in contact with large areas of diaphragm and we believe they constitute true subphrenic abscess. We have, therefore, not included lesser sac abscess on the left or infrahepatic abscess on the right, although they occur in two of the seven arbitrary anatomic spaces into which Nather and Ochsner[14] have divided the subphrenic area. Abscesses in these latter locations do not give rise to the same symptomatology, x-ray or fluoroscopic findings which are characteristic of true subphrenic abscess.

We have not tried to divide our abscesses according to any of the established classifications. We believe the abscess forms in a potential space and that the exact location of a particular abscess is difficult to determine and of no great clinical interest. Figure 1 of an induced pneumoperitoneum illustrates this potential space, some portion of which becomes occupied by subphrenic abscess. It will be noted that the liver falls forward, maintaining its relations only in the region of the bare area. For orientation we have also outlined the anterior costal margin anteriorly and the level of the first lumbar spinous process posteriorly.

Ochsner[3] claims that the most common site of infection is in the posterosuperior space which, in their classification, is a space between the liver and the diaphragm, posterior to the coronary ligament and bound inferiorly by the lower posterior border of the liver. In the Ochsner etiologic classification, however, 30 per cent of the abscesses were due to ruptured appendicitis, and he has pointed out that in this condition the most common location of an abscess is in the infrahepatic and the posterosuperior space due to spread of contamination along the peritoneal gutter. Since we now rarely see the once frequent complications of appendicitis, we must alter that statistic.

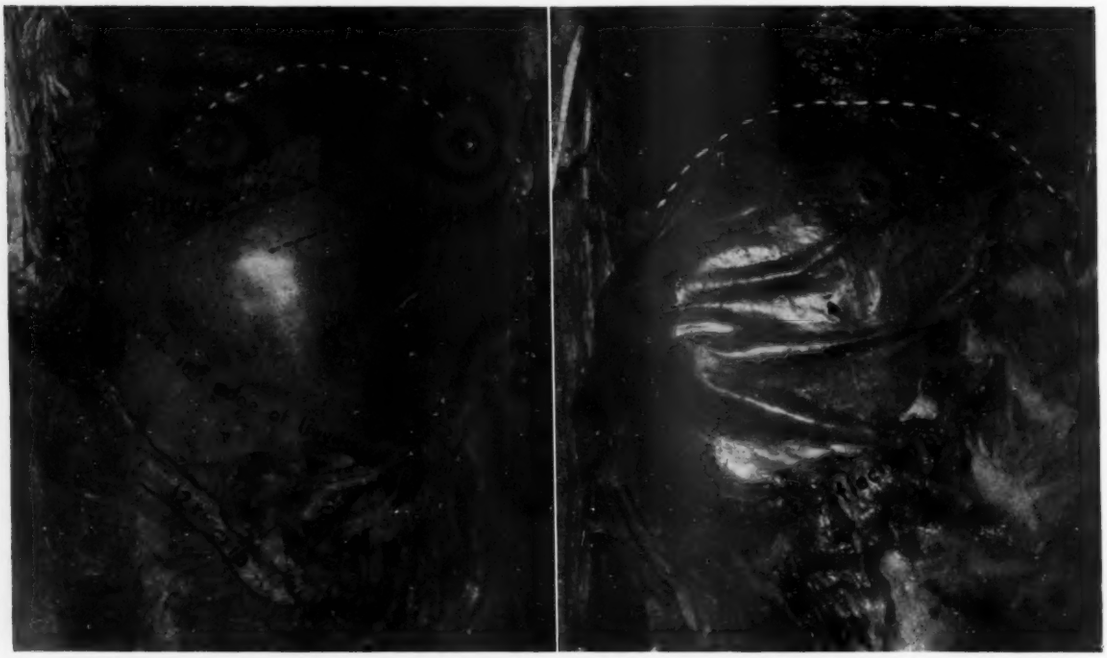

FIG. 2. The posterior chest wall has been dissected in the cadaver and a portion of lung removed to demonstrate the exact location of the posterosuperior space.

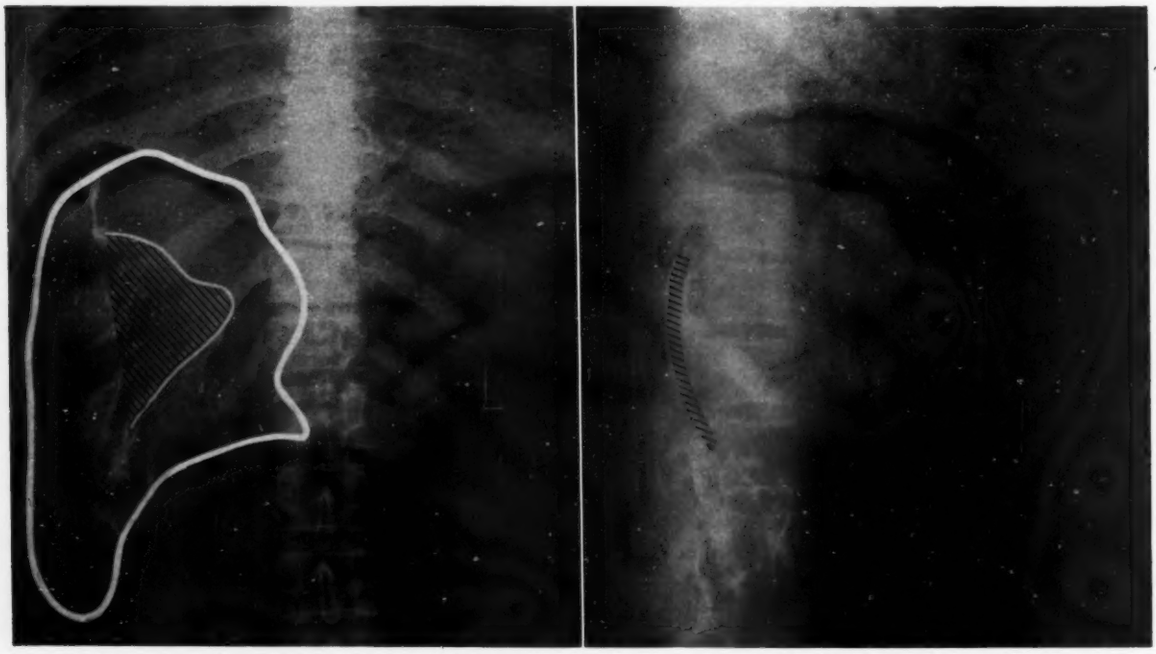

FIG. 3. Anteroposterior and lateral x-rays of the cadaver, demonstrating again the size and exact location of the posterosuperior space of Ochsner.

We have demonstrated the size of this small space (Fig. 2) in the cadaver by distending it with cotton batton and cutting a large window in the posterior chest wall so that this distended space could be photographed in the antero-posterior and lateral projections. In Figure 3 we have also demarcated this space in the cadaver with wire loops and a barium mixture, and then x-rayed the cadaver in the ordinary projections used in clinical surgury. We doubt the alleged frequence of infection in this small space which when distended will contain only about 200 cc.

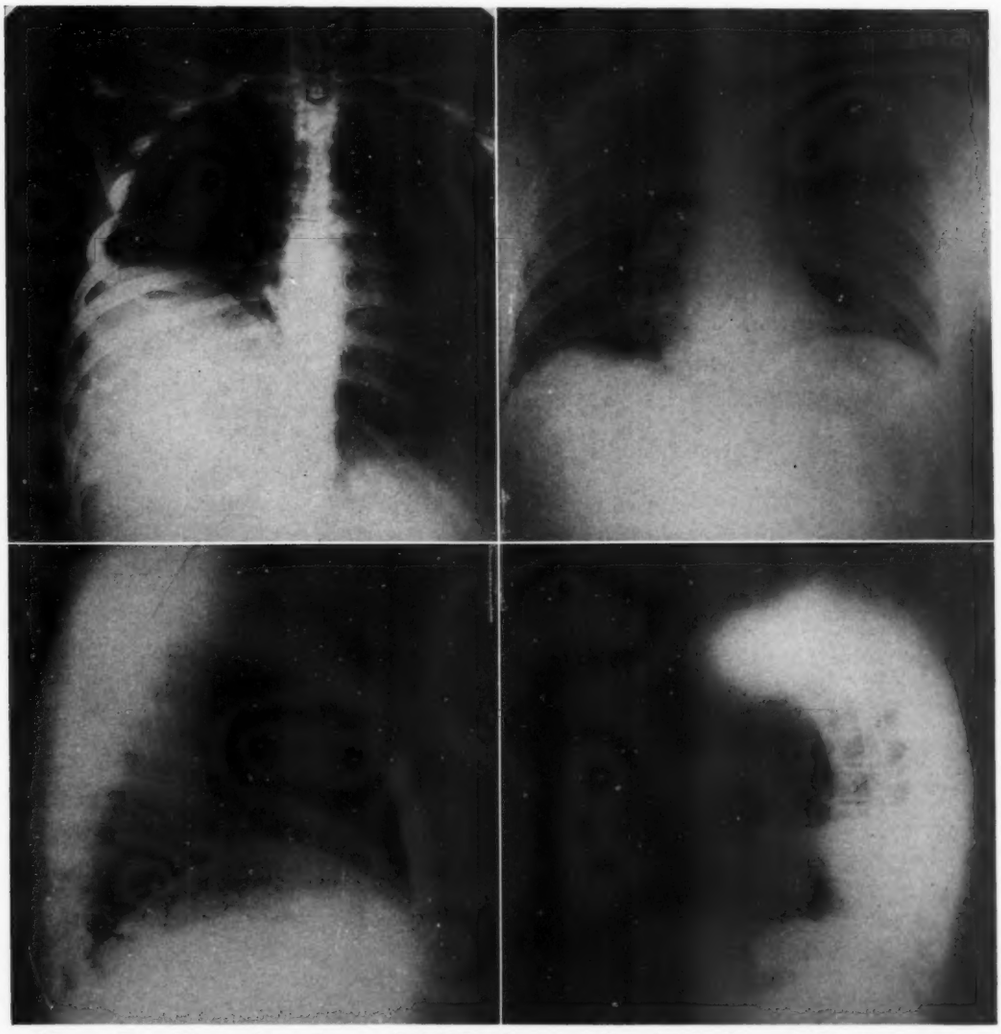

FIG. 4. Four illustrations of gas and fluid levels centered under the dome of the diaphragm.

and do not believe that involvement can be reliably diagnosed. Inflammatory involvement of that small portion of diaphragm would not be detectable by fluoroscopy nor would there be elevation of the diaphragm on the anteroposterior view of the chest. In the lateral view of the chest the spinal column and pleural effusion, if present, obscure the view of this posterior leaf so that projection would be of little assistance.

In this series we were not able preoperatively to diagnose the presence of abscess in this space. There was elevation of the diaphragm in the anteroposterior view in every instance; and the gas and fluid levels, when demonstrable, were always outside the limits of that small space. (Fig. 4.) We believe that the right subphrenic area consists of one space indented on its medial border to some degree by the right triangular ligament, that the posterosuperior space is a small portion of it and that subphrenic abscess on the right is generally centered under the dome of the diaphragm.

The liver ligaments do completely separate the right and left spaces. On the left the subphrenic abscess varies greatly in location and its relation to the diaphragm, liver, lesser omentum, stomach, spleen and colon. It would seem from the anatomy of the left subphrenic space and the variability of the location of left subphrenic abscess that posterior drainage would be hazardous. Delario[1] accepts the Ochsner-Nather classification and divides the abscesses on the right as an incidence of three in the anterior space to one in the posterior. Piquand[5] claims there is no posterior space and Lehman and Archer[6] say the posterior space is

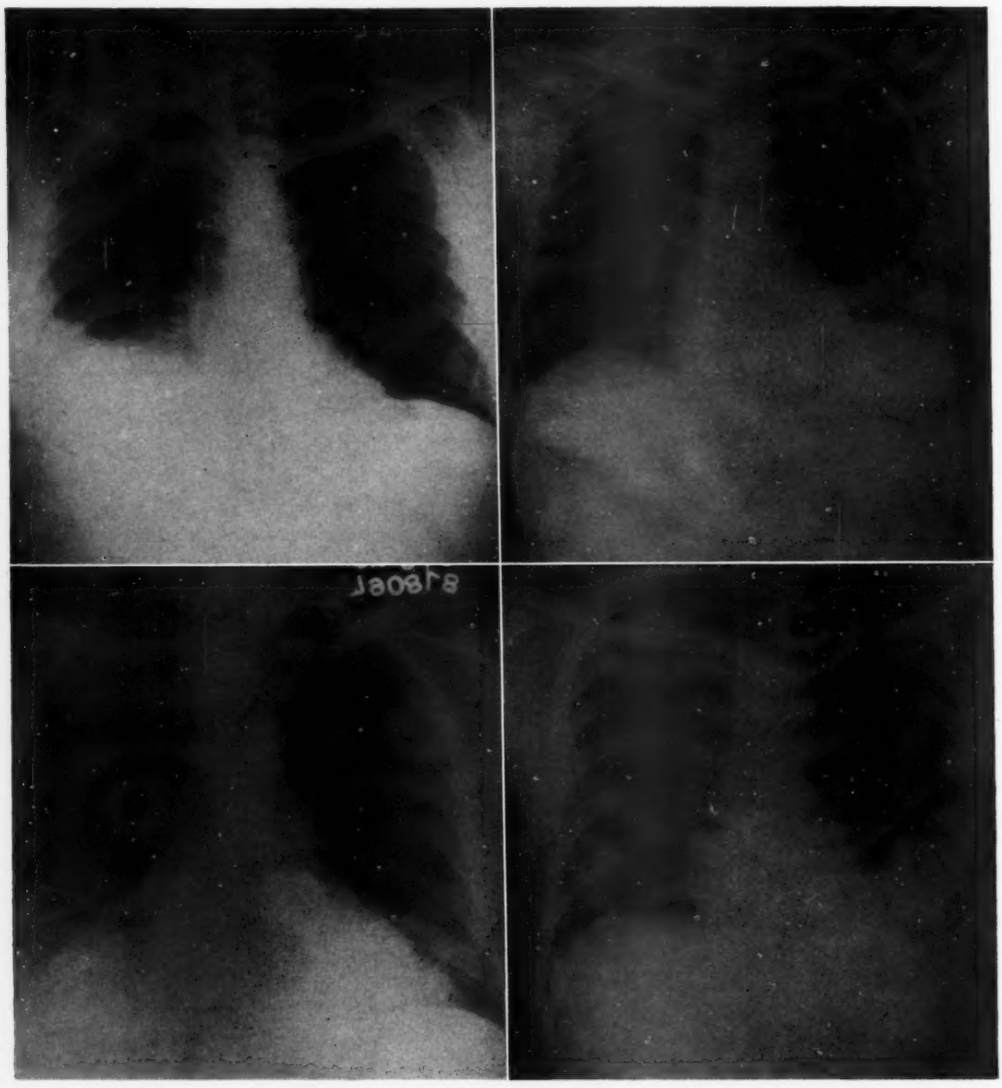

FIG. 5. The characteristic early chest x-ray findings in subphrenic abscess. There is elevation of the diaphragm, pleural reaction and patchy atelectasis.

so small that abscesses drained posteriorly are really in the posterior portion of the antero-superior space.

Diagnosis. Abscesses developed in most of our patients while they were under hospital care. It was typical that they ran an irregular febrile course, had leukocytosis, chest symptoms and very rarely back pain. The majority had no specific complaints referable to the area of the disease. Pressure over the costal margin anteriorly and over the twelfth rib posteriorly were highly unreliable signs. These patients, because they were not doing well, were early subjected to either x-ray of the chest or scout films of the abdomen. The early anteroposterior chest x-ray (Fig. 5) invariably showed an elavated diaphragm with some evidence of pleural reaction and atelectasis immediately above. This was a constant finding in this series. Although not diagnostic of subphrenic abscess, it should at least compel its consideration. The early scout film of the abdomen was not as reliable (Fig. 6) but sometimes showed a haze in the region of the upper quadrants, displacement of air containing viscera or bizarre single or multiple collections of air. (Fig. 7.) If subphrenic abscess was then suspected by the clinician or roentgenologist, lateral views of the chest and lateral decubiti films of the abdomen were ordered, diaphragmatic

FIG. 6. Early scout film of abdomen in bilateral abscess showing haze in both quadrants, medial displacement of the stomach and downward displacement of both flexures and the transverse colon.

FIG. 7. Bizarre multiple collections of air in left subphrenic abscess.

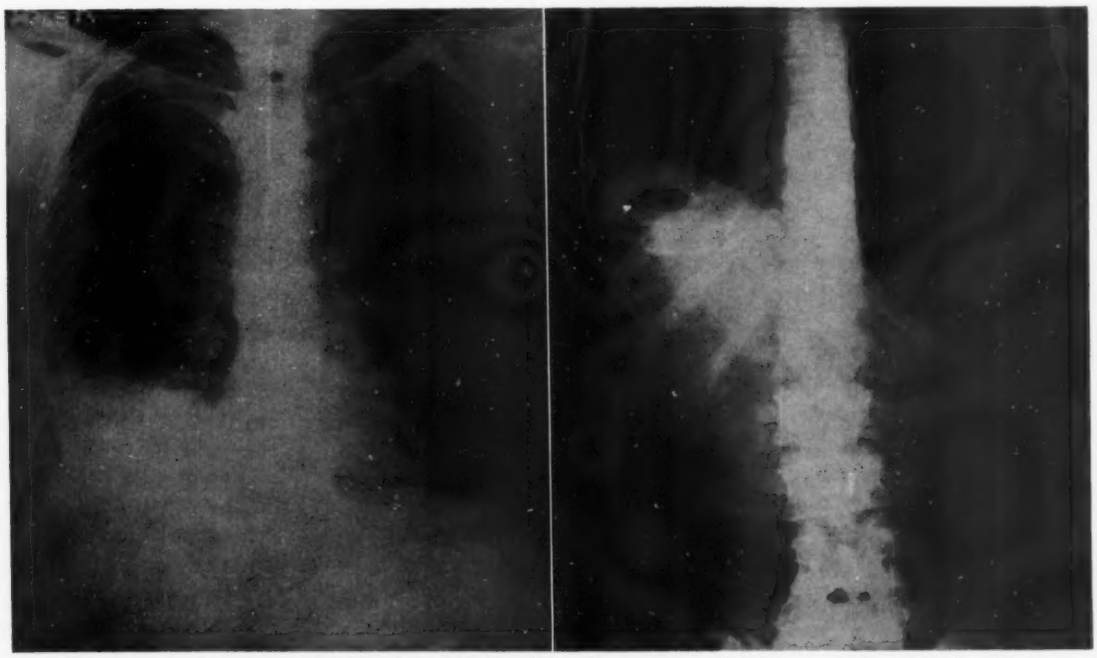

FIG. 8. Demonstration of gas bubbles beneath the right diaphragm, using heavy Bucky technic which were not demonstrable in routine posteroanterior chest film.

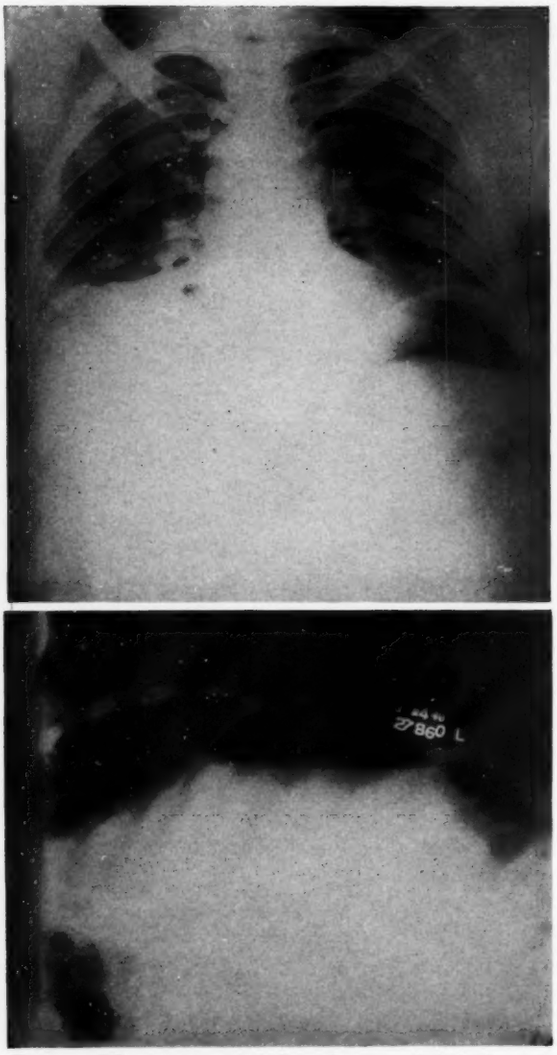

FIG. 9. The posteroanterior chest and left lateral decubiti films demonstrating large left subphrenic abscess.

motion noted on fluoroscopy and the diagnosis generally made in a matter of forty-eight hours. Sometimes, in addition, anteroposterior and lateral views of the chest were taken (Fig. 8) with a heavy Bucky technic, which sometimes demonstrates gas bubbles and fluid levels which had not been heretofore observed. Abscess on the left side is more difficult to diagnose early. A Levine tube will help to identify the location of a gas bubble as being outside the limits of the stomach. Barium ingested in the stomach or placed in the large bowel may indicate displacement of the stomach and the flexure or transverse colon by the abscess in the left upper quadrant. Decubiti films, although essential, do not as completely rule in or rule out subphrenic abscesses on the left as they do on the right, as noted by Carter.[7] (Fig. 9.)

Fluoroscopy is very important in the diagnosis of subphrenic abscess. (Table IV.) Early in the development of the abscess there is elevation of the diaphragm and some restriction

TABLE IV
FLUOROSCOPIC FINDINGS

No fluoroscopy	13
Diaphragm "elevated and fixed"	15
Diaphragm elevated with limitation of motion	12

in its motion. We disagree with Rabin[8] and believe, with McNamee,[9] that the diagnosis demands no more than restriction of motion. Fixation or absolute immobility need not be present. If bilateral abscess is present, the diagnosis by fluoroscopy is difficult since equally restricted motion of both diaphragms may be construed as normal for that patient. Elevation and some restriction of motion are present in every instance of appreciable infection in the subphrenic space.

In thirteen of our cases we had no fluoroscopic examination. In twelve instances there was only limitation of motion of the diaphragm. In two cases of bilateral abscess it was reported on all fluoroscopic examinations that "both diaphragms had normal excursion." One patient, for this reason, had drainage delayed for twelve days. There were fifteen instances of elevated and fixed diaphragms. Postoperative fluoroscopy was done in nine cases, showing return of normal motion in from three to twelve days.

Clute[10] believes that there is almost always at least a simple serous effusion in the chest when there is pus beneath the diaphragm, but we could demonstrate it by thoracentesis or x-ray in only twenty-nine of our thirty-nine cases. There were two cases of bilateral effusion. In one case the abscess was bilateral; in the second there was right subphrenic abscess with perforation of the diaphragm and right empyema. For this contralateral effusion we have no explanation. The fluid obtained by tap varied in amount from 100 to 2,200 cm. of clear, or sometimes slightly bloody, fluid. The x-ray diagnosis of effusion varied from slight to massive. Eight of our patients had thoracentesis and there were five instances of transpleural tapping of subphrenic abscess. In one instance dark bloody material was obtained which strengthened the erroneous clinical impression that the patient's disease was infected hemo-

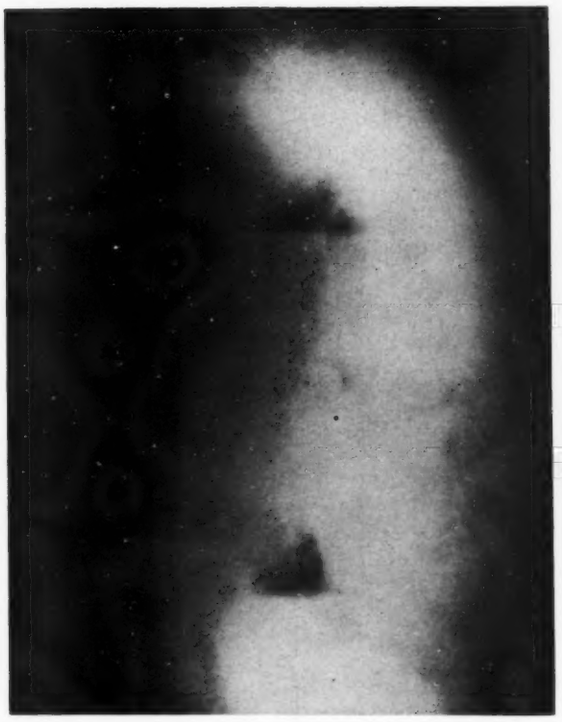

FIG. 10. Lateral chest x-ray taken on admission showing subphrenic abscess with empyema due to perforated diaphragm.

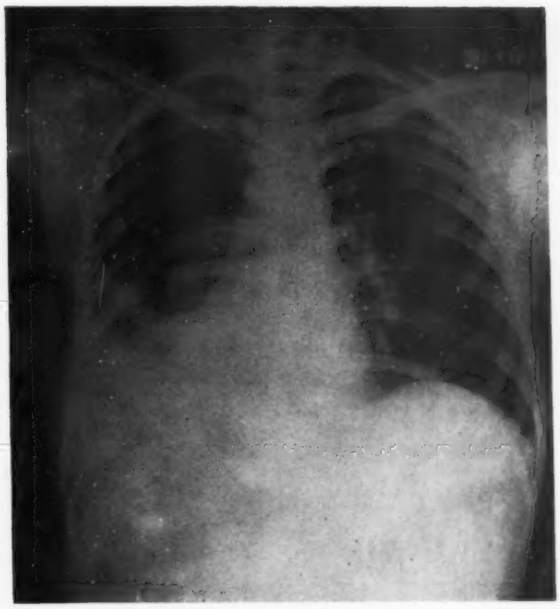

FIG. 11. Pleural effusion on the left obscuring the outline of a diaphragm elevated by subphrenic abscess.

thorax. In a second case transpleural tapping resulted in contamination of the pleural effusion, as discovered three days later when posterior drainage brought the operator accidentally into the pleural cavity. Two abscesses were tapped transpleurally several times and then operated upon for empyema. This tapping and subsequent drainage was evidently done through obliterated costophrenic sinuses. There was pleural effusion on the right in fourteen cases and on the left in fifteen cases.

The presence of pleural effusion should never distract one's attention from the subphrenic spaces. It is a common occurrence and thoracentesis is hazardous. We have five instances of unintentional transpleural aspiration of abscesses, but on no occasion was subphrenic space aspiration deliberately used for diagnosis.

Four patients had chronic abscesses of long-standing, and two of these patients had perforated diaphragms and empyema on admission. (Fig. 10.) When these conditions co-exist, the subphrenic abscess is almost invariably the primary disease. Beye[11] in 337 cases of empyema reported only one instance of perforation downward through the diaphragm, and in that instance there was a question of injury to the diaphragm during empyema drainage.

Our greatest difficulty in diagnosis was not considering this condition. The presence of wound infection or the known presence of another collection of pus, such as pelvic abscess, of which we had two, confused the issue. One patient had an undiagnosed febrile disease associated with splenomegaly. Following splenectomy this abscess was difficult to diagnose. One patient had hemothorax which is prone to be associated with fever. Atelectasis with slight elevation of a diaphragmatic leaf was thought to be obstructive in type and the diaphragmatic elevation a secondary phenomenon in several cases. Thus the early stage of the subphrenic abscess would be undiagnosed and only later the atelectasis recognized as secondary to the diaphragmatic elevation. Several of these cases were bronchoscoped for the relief of atelectasis. Sufficient pleural effusion to obscure the diaphragm in the chest x-ray encourages the diagnosis of empyema. (Fig. 11.) Also on thoracentesis, unless done very carefully, the exploring needle may easily be passed through the elevated diaphragm into the abscess which would strengthen the erroneous impression. We had two cases which were undiagnosed.

Thirty-three patients were under our observation from almost the onset of that illness

which was the etiologic factor in the development of their abscesses. (Table v.) In this group there was a spread of two to twenty-two days before diagnosis was made, with an average of 8.6 days. This compares favorably with the twenty-seven-day average reported by Doidge and Warner[12] and the fifteen-day average of Shea and Holden.[13]

TABLE V

	Average (days)	Spread (days)
Time lapse from etiologic factor to diagnosis (33 cases, 2 cases undiagnosed)	8.6	2–22
Time lapse from established diagnosis to drainage (10 patients operated on day of diagnosis)	6	1–24
Duration of all abscesses before drainage	37.5	3–300

Probably because of the antibiotics and better pre- and postoperative care the majority of the patients in this series were in from fair to good physiologic balance during their illness. There appeared to be no urgency about the diagnosis or drainage of their abscesses. The average elapsed time from established diagnosis to drainage was six days with a spread of from one to twenty-four days, and ten cases of well established abscesses were drained on the day of diagnosis. No matter how soon the diagnosis is made, an arbitrary period of about five days from onset of infection should be allowed to elapse so that the abscess will have somewhat stoutly localized itself. The average duration of abscess for all cases which were drained, however, was twenty-nine days with a spread of three to 300 days. This compares very favorably with the report of Lehman and Archer[6] of an average interval of twelve weeks from original disease to operation in fifteen cases.

It is reasonable to attempt to drain the abscess directly to the exterior without contamination of either adjacent serous cavities, and several one or two-stage methods have been advocated in the past. We have used many methods of drainage in these thirty-seven cases and some variations of established methods. Some patients were drained by different methods simultaneously, and by different methods at different times. We have many more drainages than cases because some abscesses recurred, some were drained by more than one method and some drainages required revision. One patient had an anterior extraserous and a posterior transpleural simultaneous drainage. Another had simultaneous drainage of right and left subphrenic abscesses done transperitoneally on the right and extraserously on the left. One anterior drainage was followed later with a posterior Ochsner-type drainage. Another patient had a posterior chest wall drainage through the bed of the eighth rib in the posterior axillary line. Then, two months later, the recurrence was drained anteriorly in extraserous fashion. One patient had drainages of bilateral abscesses which had to be revised twice on the right and three times on the left, making a total of seven drainages. All four drainages on the one side were extraserous and the three on the left were transperitoneal. We have charted these drainages as to location of abscess, method of drainage employed, complications encountered and the hospital convalescent days following institution of drainage. It is from this varied and extensive experience that we hope to draw comparisons.

Table VI lists the Ochsner-type drainages. The first seven drainages designated by the author's name were performed exactly as Nather and Ochsner[14] advocated. Of these, one drainage was unsuccessful; one resulted in empyema; in one case the peritoneum was entered, and a persistent sinus tract which had to be excised eight and one-half months later developed in another patient. Three cases were uncomplicated. In only two instances was pus quickly encountered, which presumes involvement of the small posterior space. In one case there was a lateral chest x-ray which was in no way unusual, and in both instances there was simultaneous great involvement under the dome of the diaphragm. Nather and Ochsner developed this method of drainage during an era when the complications of appendicitis were much more common than they are today. They have pointed out that the common location of abscess formation complicating that pathology was in the small posterosuperior and the infrahepatic spaces. It is only for such abscesses that they have recommended their posterior approach. For drainage of abscess centered under the dome this method is difficult to apply. The rigid posterior chest wall, poor visibility, and long, tortuous course through tissue spaces which must be traversed by the exploring finger

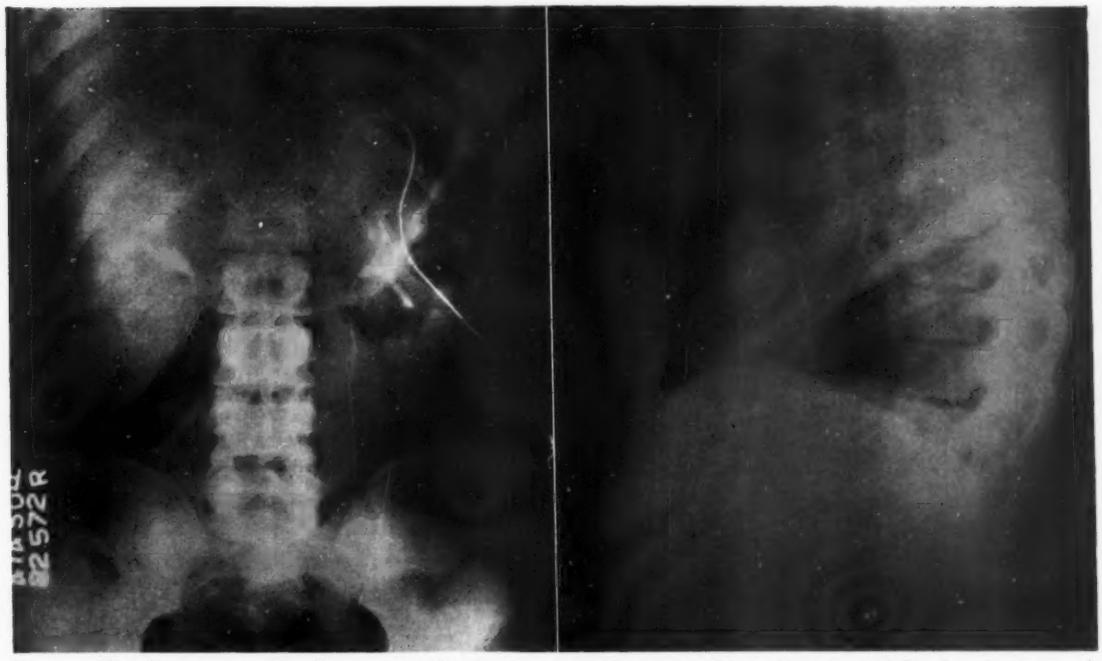

FIG. 12. Peculiar course taken by a ureteral catheter passed into a persistent sinus tract following drainage of a left subphrenic abscess.

have been commented on by others.[15] It will be noted that we have employed this method on the left which is, we believe, without precedent. Figure 12 illustrates roentgenograms taken following one left drainage. This patient had a persistent sinus which was investigated by ureteral catheter. We cannot explain these pictures but they caused great consternation.

The modified Ochsner-type drainages were so designated because the operator did not confine his activities to the level of the first lumbar spinous process, either because the proper procedure was thought inadequate in that the abscess was not located or because of ignorance of the proper procedure. These drainages resulted in five instances of pyopneumothorax. (Fig. 13.) In one of these patients a bronchopleurocutaneous fistula developed and in the

TABLE VI

OCHSNER-TYPE DRAINAGES

Location of Abscess	Drainage	Complications	Hospital Convalescent Days
Left	Ochsner	Pyopneumothorax	28
Right	Ochsner	Abscess not located, drained by another route 7 days later	17
Left	Ochsner	Sinus tract excised 8½ months later	19
Right	Ochsner	Peritoneal cavity entered	36
Right	Ochsner	None	21
Left	Ochsner	None	19
Left	Ochsner	None	42
Left	Modified Ochsner, 11th rib	Pyopneumothorax	25
Right	Modified Ochsner, 11th rib	Pyopneumothorax, required decortication	38
Left	Modified Ochsner, 12th rib	Pyopneumothorax, pleura entered	33
Right	Modified Ochsner, 12th rib	Pyopneumothorax, pleura entered	16
Right	Modified Ochsner, 11th—12th rib	Empyema, bronchopleurocutaneous fistula	46
Left	Modified Ochsner, 12th rib	None	11

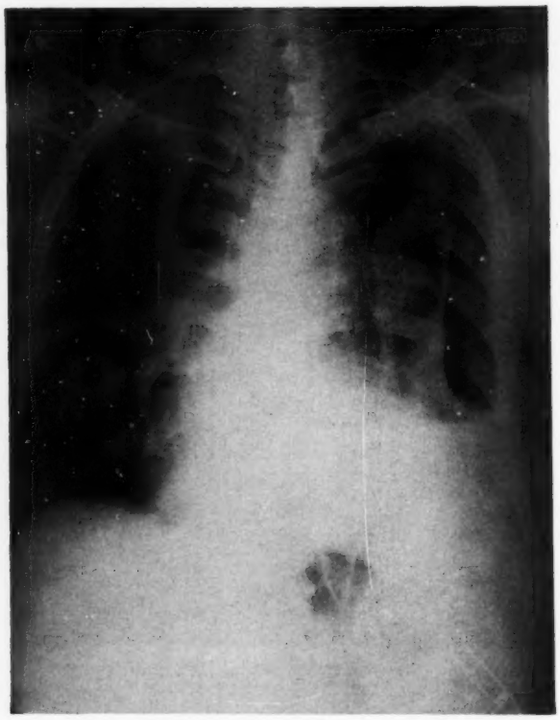

FIG. 13. Pyopneumothorax following deviation from proper procedure when using Ochsner-Nather posterior drainage.

second, an empyema which required decortication. Only one drainage of the modified Ochsner-type was uncomplicated. Thus the method itself, when correctly applied to the drainage of our subphrenic abscesses, was not very successful and deviation from it proved quite hazardous.

Table VII lists the other posterior chest wall drainages. The first drainage through the eighth interspace was instituted because the operator did not diagnose a perforated diaphragm. He had drained a subphrenic abscess by an anterior extraserous route and thought its high posterior extension was retropleural. This patient, however, promptly got well and left the hospital in eighteen days. A second instance of perforated diaphragm was diagnosed but it was decided to drain the empyema first. This was done without benefit to the patient who, at autopsy four days later, was found to have a large open perforation of a gastric ulcer in communication with a subphrenic abscess and empyema. The third patient was thought to have either an empyema or an infected hemothorax because it was not realized that a subphrenic abscess was being tapped transpleurally. The chest was opened through a thoroacotomy incision and the pleural space found uninvolved. The diaphragm was then opened, the subphrenic abscess evacuated and a drain placed transperitoneally, coming out in the region of the ninth rib anteriorly through a stab wound. The diaphragm was then closed above the drain and a thoracotomy tube placed in the patient's chest. He recovered and went home on the twenty-second day. The next two cases were thought to be empyemas and only after the pus was removed from the cavity was it realized that it came from the subphrenic space. One of these patients had had a previous unsuccessful rib resection for drainage of empyema and the operator noted as he went through the diaphragm that the "parietal pleura" of the chest wall was 4 mm. in thickness. The last patient was drained through the tenth interspace in the posterior axillary line in

TABLE VII

OTHER POSTERIOR CHEST WALL DRAINAGES

Location of Abscess	Drainage*	Complications	Hospital Convalescent Days
Right	8th interspace chest wall simultaneous anterior extraserous drainage	Perforated diaphragm, empyema	18
Right	8th rib P.A.L.	Perforated diaphragm, empyema; death in 4 days	..
Right	7th rib P.A.L. and 9th rib A.A.L.	Thought to be empyema; no complications	22
Right	8th rib P.A.L.	No immediate complication; recurred 2 months later	27
Left	9th rib P.A.L.	None	11
Right	10th interspace P.A.L.	None	17

* P.A.L. = posterior axillary line; A.A.L. = anterior axillary line.

conjunction with a true Ochsner-type drainage through which the operator could not localize the abscess. When aspiration through the tenth interspace yielded pus, the needle was cut down on in that location and the abscess drained. The recurrence was drained later by a more conventional method. The three uncomplicated cases are explainable only on the basis of firm adhesions in an obliterated costophrenic angle.

This group has been discussed in some detail to point out that although we do not deliberately practice transpleural drainage, which some still advocate,[8,16,17] we have been forced to it by confusion or expedience. In each case in which infection was introduced into the pleural space by the operator the error was detected within twenty-four hours and the pleural cavity contamination treated by thoracotomy tube drainage to a water-seal bottle. It is an arresting point that although only two empyemas occurred spontaneously, there were six empyemas in this series caused by surgical drainage of subphrenic abscesses. Although four of the six patients had relatively uneventful postoperative courses despite pleural contamination, two of them did not. One ultimately had a pleural cavity decortication and the other recovered slowly from a bronchopleurocutaneous fistula. There were no deaths.

Table VIII lists a remarkable group of nineteen transperitoneal drainages done on twelve patients with only one instance of the complication of ileus. This was a severe ileus which required long tube intubation for eleven postoperative days. A second patient was found subsequently to have a pelvic abscess for which the method of drainage may have been responsible. His subphrenic abscess followed an elective splenectomy. We had one other instance of pelvic abscess in this series which followed a stab wound of the abdomen. That pelvic abscess was drained first. A subsequent transperitoneal drainage of the subphrenic abscess did not result in further abscess formation in the peritoneal sac. The death following gastrectomy was not related to the method of drainage and is discussed later. Some of these subphrenic abscesses were found on exploratory laparotomy and were thus necessarily drained transperitoneally. In four instances this method had apparently been deliberately chosen. Since one-half of these drainages were uncomplicated and with no deaths directly attributable to the subphrenic abscess *per se*, this must be considered a feasible method. One must further conclude that the antibiotics and other modern adjuncts are of great assistance in preventing and treating disseminating infection for in the Ochsner and Graves[18] collective review this method showed a mortality of 42.8 per cent.

TABLE VIII
TRANSPERITONEAL DRAINAGES

Location of Abscess	Complications	Hospital Convalescent Days
Left	Severe ileus for 11 postoperative days	16
Left	? of subsequent pelvic abscess	56
Right	2 transperitoneal revisions	47
Left	2 transperitoneal revisions	53
Left	2 transperitoneal revisions	53
Right	1 transperitoneal revision	90
Right	None	22
Right	None	23
Right	None	17
Left	None	12
Right	None	36

Table IX shows the extraserous drainages. There was one death in this series related directly to subphrenic abscess. There was failure to diagnose because it was bilateral and the fluoroscopist believed that both diaphragms exhibited normal motion. Eventually the left subphrenic abscess was diagnosed and then only the left abscess drained. By that time the patient was in precarious condition and expired four hours after that late and inadequate drainage. One patient required three revisions and a second case, one revision. There were two deaths in this group following gastric surgery. These deaths were not due principally to abscess or the method of drainage employed and are discussed in detail later. Using this method eight cases were uncomplicated, and two others required only revision of the drainages. We agree with Clagett and Tinney[19] that this method of drainage first described by Clairmont is the soundest surgical procedure. By this route either right or left subphrenic space may be drained. With almost universal employment of early ambulation this method supplies as dependent drainage for the right subphrenic space as does the Ochsner method. On the left, where the liver does not help one preserve his landmarks, the fact that the peri-

toneum is easily stripped from the diaphragm permits extraserous exploration until the abscess is located.

In Table x we grossly compare the results obtained by the four methods. We have considered death, recurrence of abscess and gross clinical

TABLE IX
EXTRASEROUS ANTERIOR DRAINAGES

Location of Abscess	Complications	Hospital Convalescent Days
Bilateral	Only left abscess drained; death in 4 hours	..
Bilateral	Required 3 revisions	53
Right	Required 1 revision	42
Right	None	12
Right	None	32
Right	None	19
Left	None	12
Right	None	30
Right	None	12
Right	None	42
Right	None	17

contamination of pleura or peritoneum as serious complications. We have, however, excluded the three deaths following gastric surgery. It will be noted that the percentage values in each column are in reverse order.

Three of our six deaths (Table XI) followed gastric surgery, two patients having had total gastrectomy. All three had breakdown of the anastomoses, two proved by autopsy and the third by the development of a demonstrable gastrocutaneous fistula on the ninth postoperative day. We shall describe them in some detail to explain their omission from some of our statistics. The first total gastrectomy had a normal temperature until the fifth postoperative day when the roentgenologist described air in the left upper quadrant, an elevated left diaphragm with pleural reaction and atelectasis, but did not make a specific diagnosis of subphrenic abscess. On the seventh postoperative day there was sudden onset of upper abdominal pain thought due to rupture of a suture line, but at operation was found due to rupture of a well established left subphrenic abscess. Autopsy showed anastomotic breakdown, left subphrenic abscess, diffuse peritonitis, and hydrothorax. The second total gastrectomy ran an irregular febrile course with leukocytosis (21,600) from time of operation. Six days later he had a cecostomy performed because of great distention of the proximal large bowel which was probably due to the subphrenic abscess but, at the time, was considered due to constriction of the colon by the loop of small bowel brought up anterior to it for purpose of anastomosis

TABLE X
COMPARISON OF METHODS OF DRAINAGE

Method	No Complications (Per cent)	Serious Complications (Per cent)
Extraserous anterior.....	72	9
Transperitoneal.....	50	20
Posterior chest wall.....	50	33⅓
Ochsner-type.....	30.7	50

X-ray showed an elevated diaphragm with pleural reaction in the left base twenty-four hours after surgery and an unexplained gas bubble on the fifth postoperative day, but not until the ninth day was a specific diagnosis of left subphrenic abscess made and drainage instituted. His condition did not improve, jaundice supervened and, five days later, autopsy

TABLE XI
DEATHS

Etiology of Abscess	Location	Cause of Death
Total gastrectomy	Left	Chronic gastrointestinal perforation
Total gastrectomy	Left	Chronic gastrointestinal perforation
Subtotal gastrectomy	Left	Chronic gastrointestinal perforation
Ruptured gastric ulcer	Right	Chronic gastrointestinal perforation ? inadequate drainage
Ruptured duodenal ulcer	Bilateral	Right not diagnosed; delayed drainage of left
Ruptured duodenal ulcer	Left	Undiagnosed

showed breakdown of the esophageal anastomosis, left subphrenic abscess and diffuse peritonitis. The third patient had two chronic gastric ulcers for which subtotal gastrectomy was done. Following surgery there was irregular fever and leukocytosis. The abscess was diagnosed by x-ray seven days after operation by

which time a gastrocutaneous fistula had developed. The abscess was drained on the twelfth postoperative day. However, the patient continued his downgrade course and in the last two days of life hemorrhaged severely from the drained wound.

A fourth death occurred in a patient with a chronic abscess. This patient entered the hospital after two months of severe illness. Two weeks prior to admission the abscess perforated the diaphragm and dyspnea supervened. On admission he was emaciated and exhausted. It was decided to drain the empyema first, which was done in forty-eight hours following admission, and undigested food was removed from the right pleural sac. Following empyema drainage the patient's condition did not improve and autopsy showed gastropleurocutaneous fistula due to perforation of chronic gastric ulcer. It is difficult to ascribe this death to subphrenic abscess with thoracic complication in the presence of continuing perforation of the gastric ulcer, but drainage of a subphrenic abscess through the bed of the eighth rib in the posterior axillary line cannot be considered adequate. The fifth death occurred in a patient having two duodenal ulcers, one of which perforated forty-eight hours before admission. Following the repair of the perforation the patient did poorly. The clinicians thought his difficulties due to wet lung and atelectasis. He was fluoroscoped many times and had six bronchoscopic aspirations. X-ray diagnosed subphrenic abscess on the third postoperative day, but as fluoroscopy showed no difference in excursion of the two diaphragms, the diagnosis was not accepted. Also, gross wound infection developed. However, the clinical diagnosis of left subphrenic abscess was made on the tenth postoperative day and drainage instituted, but the patient died forty-eight hours later. Autopsy showed bilateral subphrenic abscess which explained why both diaphragms had the same range of motion. The last death occurred in a patient admitted very seriously ill three days after duodenal ulcer perforation. The clinical diagnosis was ruptured viscus with generalized peritonitis. His abscess was not diagnosed by either the clinicians or by x-ray, although on admission the x-ray showed the left diaphragm elevated by distended bowel. He died on the fifth day and a large left subphrenic abscess was found at autopsy. There was also diffuse peritonitis and a left hydrothorax.

Three deaths, then, were subsequent to gastric surgery with breakdown of anastomoses and a fourth occurred in chronic subphrenic abscess complicated by perforation of the diaphragm, empyema and continuing gastric leakage. The fifth death was in bilateral abscess with delay in diagnosis and drainage. The sixth was due to failure of diagnosis. Only the last three deaths can be considered due to unrecognized or ill treated subphrenic abscess. This gives a corrected mortality of 7.7 per cent. Since the first recorded drainage by Volkman in 1875 the mortality in this abscess has steadily fallen. It has been recorded as 75 per cent (McEachern) and 100 per cent (Lotsch) in unoperated cases. Ochsner[15] has pointed out that the higher mortalities were due to late diagnosis and transpleural and transperitoneal contamination. Our patients' deaths were due to failure to diagnose, delay in diagnosis and inadequate drainage.

SUMMARY

1. A true subphrenic abscess is one which is in contact with an appreciable portion of diaphragm. We would exclude lesser sac, right posterosuperior space and infrahepatic space abscesses from this category.

2. The right subphrenic area may then be considered as one space with the majority of both right and left abscesses centered under the dome of the diaphragm.

3. Subphrenic abscess occurs often in abdominal trauma and sometimes without perforating injury of the gastrointestinal tract.

4. We demonstrate in this small group that antibiotics and other modern adjuncts have reduced the hazard of transpleural and transperitoneal contamination.

5. The safest and soundest surgical procedure for drainage is the anterior extraserous approach of Clairmont.

6. Our uncorrected mortality of 15 per cent, however, is not an improvement over that achieved in the pre-antibiotic era.

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ABDOMINAL INJURIES

WITH SPECIAL REFERENCE TO ERRORS IN EARLY HANDLING

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New York, New York

OUR present renewed interest in civil defense again emphasizes the importance of the management of wounds and injuries. Early care in all is most important, but especially is this true in abdominal injuries with hemorrhage, shock and possible spreading peritonitis.

Modern treatment has as its foundation the principles developed in World War II.[1] A vast knowledge was accumulated at that time and was recorded in many articles, but especially noteworthy were those written by Rankin[2] and Churchill.[3] The surgeon today should be thoroughly familiar with all that was learned in World War II, as well as the more recent advances in transportation methods, antibacterial agents, blood banks and replacement therapy. However, even with the newer gains, it must still be kept in mind that during war and catastrophe, as Churchill says, "The surgery of trauma is encountered in epidemic proportions," and procedures must be adapted to meet existent conditions and technics have to be simplified and streamlined.

Classification. Abdominal injuries may be divided into penetrating and non-penetrating types. The seriousness of the latter depends usually upon the extent of the associated intra-abdominal or visceral injury. We have observed, however, a patient suffering from a large hemorrhage in the abdominal wall from a ruptured deep epigastric vein, the result of his being struck by a log while swimming.

Rupture of almost every organ within the abdomen has occurred without external signs of injury. Such trauma is often produced by blows, falls, blasts, car wrecks and similar accidents. Rupture of diseased organs is noted in malignancies, ulcers, cysts, obstructions, aneurysms, infarcted organs and ectopic pregnancies. In this article we are primarily interested in the serious intra-abdominal injury and its early handling, regardless of etiology.

TRAUMATIC SHOCK

Ogilvie[5] says, "People with abdominal injuries die from hemorrhage, shock or infection. In the first few hours they die from hemorrhage, in the first two days from shock, of which hemorrhage is the chief cause, and later from infection." All abdominal injuries are prone to be followed with some degree of shock, and it is essential to realize that approximately 50 per cent[4] of the deaths produced by penetrating abdominal wounds are the immediate result of hemorrhage and shock.

The mechanism of traumatic shock has been variously described.[6–10] In essence it is a series of events following the reduction of the effective blood volume. The amount of circulating blood is reduced by hemorrhage and fluid loss from the injured parts. In order to compensate for the reduced venous return of blood to the heart, reflex vasoconstriction is produced, usually accompanied with a slight elevation of the pulse. If the loss of circulating blood stops before an indefinite point, restitution of the blood volume is made up by dilution. With further loss of blood and fluids, there is a decreased cardiac output and the blood pressure begins to fall. There is a progressive anoxia of the tissues with resulting damage to vital organs such as the brain, heart, liver and adrenals. Indeed, anoxic liver damage is regarded by many to be one of the most serious phases of shock. If there is extensive gross destruction, the shock is intensified with particularly severe effect upon the kidneys. The shock picture is made infinitely worse when, with intra-abdominal hemorrhage, a leaking wound of the intestinal tract is associated with early developing fulminating peritonitis.

Examination of the Patient with Shock. Laboratory tests for shock, including the hematocrit, are apt to be misleading. The hemodilution that occurs in hemorrhagic shock and the hemoconcentration sometimes associated with burns and fulminating peritonitis are reflected in the hematocrit only after several hours have elapsed.[11] A falling blood pressure still remains the vital criterion of shock. Blalock[7] states that when the systolic blood pressure readings are in the range of 80 to 100 mm. of mercury, the blood loss has

usually exceeded 25 per cent. If the blood pressure is 60 or below, there is a likelihood that the blood loss has been 35 to 40 per cent of the total volume. If a vein of an extremity is emptied by pressure, the refilling time is greatly delayed in shock. The raising and lowering of the head a few degrees is a helpful test, for if the blood pressure improves with very slight Trendelenburg, one may anticipate an early response to blood or fluid. According to the degree of shock, the patient will usually present any or all of the following signs: apathy, cool moist skin, ashen color, lowered blood pressure, small pulse with increased rate, labored respiration and vomiting.

Treatment of Shock. In the treatment of shock due to hemorrhage, whole blood is the most reasonable therapeutic fluid. Blood derivatives such as frozen, dried or fluid plasma, or serum albumen may be used, but they are expensive and not readily available. Furthermore, with plasma the risk of homologous serum jaundice is always present. Of course, normal saline or any of the aforementioned may be given until blood is secured.

Many therapeutic agents, known as stimulants, are inadvisable in shock and may do harm. Vasoconstrictors such as adrenalin and ephedrine increase the already existent vasoconstriction and tissue anoxia. Because of this ever present danger, nor-adrenalin[12] is often impractical to use, requiring as it does careful supervision rarely offered in the average emergency ward. The patient is best maintained at room temperature. A heated skin makes metabolic demands that the body can ill afford to meet, although chilling may add to tissue anoxia and result in further bleeding. Mild Trendelenburg position is often advantageous; however, rapid maneuvering to the extreme position is dangerous. Since venous return from the brain is principally by gravity, a significant lowering of the patient's head may impede this return and lead to cerebral congestion and anoxia. Following the administration of blood, if the pressure can be maintained around 85 mm. of mercury, one feels a certain safety in proceeding with further handling of the case. If between 2 to 4 pints of whole blood are ineffective in maintaining the blood pressure at this level, we assume that vigorous bleeding is occurring, and the patient is prepared for immediate surgery.

When there is complete collapse of the veins, as in extreme and sudden shock, we have had phenomenal success on a few occasions with arterial transfusions.

Oxygen by inhalation may be used in any case but it is most advantageous when there are associated chest wounds, burns or any degree of respiratory embarrassment.

Cardiac stimulants have no place as the damage does not rest in the heart, nor do the cerebral stimulants, such as metrazol, have a logical use.

IMMEDIATE HANDLING OF PATIENTS

If the patient is in pain, a proportionate dose of morphine is administered, if necessary, by the intravenous route.

Tetanus and gas antitoxin should be dispensed early. Every case should have an initial standard dose of some antibiotic, with further dosage to be determined by later findings. It is essential to record vital signs and chart the fluid intake and output. Frequent aspiration of the pharynx and trachea is imperative particularly in thoracico-abdominal wounds. The insertion of a gastric tube is both diagnostic and therapeutic. In the critically injured, gastric function temporarily ceases, resulting in acute gastric dilatation. This impinges on the left side of the diaphragm, reducing pulmonary ventilation, a highly undesirable event at a time when the patient requires the fullest respiratory exchange. Abdominal muscular splinting also reduces the vital capacity by reducing the costal excursion and here it is sometimes advisable to block the ninth to twelfth thoracic nerves to alleviate the condition.[13]

A careful examination for associated injuries must always be performed. Important diagnostic aids are signs of external violence, wounds, bleeding from the rectum, bloody vomitus or bloody aspirated gastric contents, hematuria, or shoulder pain (diaphragmatic irritation). The perineum and back should be examined for wounds of entrance. These wounds occur in explosions or bursting shells and are often at first overlooked. Sharply demarcated abdominal spasm may suggest thoracic rather than abdominal injury. The abdominal distention of spinal injury appears early in contradistinction to the distention of peritonitis. Shifting dullness and less often the absence of liver dullness are highly significant. Auscultation should never be neglected. Proctoscopic, manual rectal examination and catheter-

ization are imperative. X-ray examination is indeed a fruitful source of information.[14] The presence of free air is usually indicative of a perforation of the stomach or colon. However, paralytic ileus must be present for a perforation of the small bowel to produce free air. An appreciable intra-abdominal clot may produce a significant shadow on a scout film. A ruptured spleen often reveals a hazy shadow displacing the stomach or colon. Free air introduced into the urinary bladder producing a pneumoperitoneum is indicative of bladder rupture. A perineal hematoma may produce a faulty outlined or absent psoas shadow on a scout film.

Peritoneoscopy or diagnostic needle aspiration, although occasionally informative, is dangerous and often misleading. Probing of external wounds is to be condemned.

Local Wounds. The initial wound treatment consists of dry sterile gauze and strappings. Antiseptics such as iodine and alcohol can leak into or be sucked into the abdominal cavity. Because of possible spread of infection the treatment of *entrance* and *exit* wounds is to be deferred until the laparotomy is completed. The proper treatment of these wounds is excision and closure with or without drainage. The performance of the laparotomy incision through the traumatic wound is dangerous and often leads to subsequent spread of infection and breakdown of the wound.

OPERATIONS FOR ABDOMINAL INJURIES

The decision as to the best moment for operation is at times very difficult. If a blood pressure of 85 mm. of mercury or above can be maintained together with signs of subsiding vasoconstriction, as warm skin and slowing pulse rate, the operation may proceed. If operation is delayed at this time, blood is wasted, peritonitis may progress and an increase in mortality is almost certain. If the patient fails to respond to the shock treatment and after the administration of 2 to 4 pints of whole blood, there must be continued intraperitoneal bleeding and possible further spread of infection. To decide whether or not to operate on a patient at this point requires all the surgical judgment one can muster, but in spite of the patient's clinical condition, surgical intervention may save his life.

We prefer having needles in the veins of both lower extremities with sufficient additional blood easily available. A gastric tube is always *in situ* and the patient's abdomen is prepared after anesthesia has been obtained. Transverse or unusual incisions are avoided,[15] and great stress is placed upon the necessity of several glove changes during the procedure. Penicillin in the amount of 1,000,000 units per L. is introduced into the parenteral fluid during the operative procedure. In this manner an effective antibiotic blood level is immediately obtained and is effectively operating during the surgery. At no time do we introduce powdered or crystalline antibiotics into the peritoneal cavity; they are irritating and adhesions so produced are frequent causes of intestinal obstruction. We have operated upon seven such patients. In closing the abdomen the threat of subsequent evisceration should be uppermost in one's mind.

Stomach. Stomach injuries are often associated with injuries to the diaphragm or other neighboring organs. Single stomach perforations are customarily associated with ulcer, malignancy or the misuse of the gastroscope. We saw a case in which ether was introduced into the stomach instead of the lungs, an explosion followed, the patient died, and autopsy revealed stomach lacerations in several directions. Pain is usually very severe; hemorrhage is present to a degree, occasionally in great quantity. There is early localized peritonitis which spreads slowly. The white blood cell count is more often immediately elevated to between 14,000 and 20,000. Retching and attempts at vomiting are conspicuous. For exposure we elect a high midline incision from the ensiform cartilage to the umbilicus. Further exposure of spleen or liver lacerations may require extending this incision across one or both recti muscles. Furthermore, the incision may be extended through any of the costal cartilages to the chest or heart. We rarely find it necessary to cut the suspensory ligament of the left lobe of the liver. The latter may be retracted very easily with a Dever retractor covered with a piece of gauze. Traction on the greater curvature of the empty stomach brings the stomach well into view. Resection is rarely necessary. Simple double layers of sutures suffice even in large wounds. If the left diaphragm is injured, this may be sutured through the abdominal incision. Even the smallest wounds in the left diaphragm should be sutured because within a few months or years they tend to enlarge and

visceral herniations occur to such a degree that one must follow such a case to believe it. The decision to open the chest and the location of the incision is often determined by the nature of the trauma, particularly in the case of a missile wound when the tract is obvious or can be reconstructed. We do not favor a thoracico-abdominal incision unless it is absolutely necessary.

Duodenum. We have noted that these injuries result primarily from non-penetrating trauma. Individuals may sustain such injuries from falling ceilings, horse kicks or blows from the blunt end of a pole. Hemorrhage and shock are severe, and the mortality is exceedingly high. We observed one case in which the common duct was torn from the duodenum. A well functioning gastric tube is imperative; and if there is any interference with the drainage of the common duct subsequent to repair, introduction of a T tube or a catheter may be advisable. The closure should be carefully performed with non-absorbable sutures and drained to the suture line. Should the suture line break down following the removal of the drain, an immediate operation with suction drainage may prove life-saving.

Small Bowel. From one-quarter to one-third of all abdominal injuries involve the small bowel alone. If bleeding is apparent on opening the abdomen, our primary effort is its immediate control. Our attention is next directed to the large bowel and any injury here is immediately repaired so that further contamination from this most soiling segment is abruptly halted. Gloves, instruments and soiled abdominal pads should be changed frequently. We now turn to inspection of the ileum. Bowel perforations are notably even in number. When they are detected, inspection of the bowel 2 or 3 feet proximally and distally is indicated prior to suturing, for should several perforations be noted within a short distance, the best method of closure may be segmental resection. In resections we favor end-to-end closures with interrupted fine chromic on the inside and non-absorbable interrupted sutures on the outside. Lumen patency should always be tested after performing an anastomosis. In order to avoid soiling we place proximally a bowel tourniquet consisting of a piece of umbilical tape twisted or gently tied about the bowel through a tiny opening at the mesenteric border. Transverse wounds of the mesentery may require bowel resection. Postoperatively a tube is maintained in the stomach and at intervals in the rectum, and the patient receives nothing by mouth until flatus is passed, which may occur as late as the third or fourth postoperative day.

Large Bowel. The large bowel is injured alone in more than one-third of abdominal injuries involving the colon. There is a marked correlation between shock and mortality in large bowel trauma with fecal contamination being the devastating factor in shock production. In addition to the instruments of war, bullets, knives, sigmoidoscopes, objects chosen by the psychopathic, obstruction and immersion blast have all been implicated as causative agents. In crushing fractures of the pelvis there is often associated bladder or large bowel injury. In immersion blast the cecum is frequently damaged, and mesenteric and retroperitoneal hematomas are commonly accompanying lesions.[16] Contusion, hematomas, bleeding anaerobic infection, gangrene and secondary perforation are not unusual and all are more common in large bowel than in small bowel injuries. Many of the perforations will seal off, present a false safe period and later break open. Others, however, reveal no tendency to close and present a picture very much like a perforated duodenal ulcer. At operation frequent change of gloves and instruments is again highly desirable, and at all times the small bowel should be walled off with gauze pads. If indicated, fixed portions of the large bowel should be mobilized to avoid leaving hemorrhages and retroperitoneal perforations. Resection is rarely necessary and carries a high mortality, although with gangrene, infarction and crushing injuries it is imperative. Although exteriorization is often the treatment of choice, particularly on the left side, suture with proximal colostomy is frequently more advantageous, because extensive mobilization necessary for exteriorization is a vastly shocking procedure.[17]

Exteriorization of an injured segment of bowel, or colostomy to divert the fecal stream, each require adequate mobilization of bowel. Bowel loops must lie comfortably and without tension on the abdominal wall, for retraction leads to spread of infection and the formation of fistulas. Bowel loops are never brought out through the wounds of entrance or exit nor through the laparotomy wound.

Sigmoid colostomies are used when there are injuries to the pelvic colon, the rectum or large wounds of the perineum and gluteal region.

Transverse colostomies are used when a cystostomy is also necessary and when there are extensive pelvic or lower abdominal injuries which will require future reparative surgery.

A cecostomy will not divert the fecal stream. It has a limited use only as a safety gas valve to prevent increased tension on a suture line.

Right colostomies may be used along with an ileostomy when extensive damage has been done to the cecum and ascending colon. In such case the ileostomy is performed through a small incision in the right lower quadrant and the colostomy through a similar incision below the right rib margin. Following such procedure early anastomosis should be performed.

Sometimes the ileum can be sutured to the transverse colon and the stump of the latter brought out through a separate wound, drains being placed through stab wounds to the right lower quadrant.

Rectum. Intraperitoneal rectal wounds carry a mortality of approximately 35 to 40 per cent as against 5 to 8 per cent for extraperitoneal wounds. Intraperitoneal wounds are often associated with bladder and pelvic injuries, and suprapubic tenderness and rigidity are generally present. A left rectus incision is advantageous, the performance of a routine colostomy imperative, and drainage of the pelvis through the anterior abdominal wall indicated. Extraperitoneal wounds are occasionally unrecognized because a digital or proctoscopic examination is overlooked. The routine use of colostomy and wide retrorectal drainage below the coccyx or division of the rectal sphincter is sound.

Liver. The liver is damaged in approximately 15 to 20 per cent of all abdominal injuries and frequently is the only viscus injured, particularly in non-penetrating wounds. Hemorrhage is severe but a temporary cessation, the so-called deceptive or time lag period, followed by recurrence of bleeding, is not uncommon. In cases of doubt we have a general rule to open the abdomen through a minute incision and if blood, gas or intestinal contents are noted, to enlarge the incision and proceed with the operation.

When the injured liver is exposed, the operator or his assistant, preferably the latter, should apply digital pressure to the free edge of the gastrohepatic omentum, thus compressing the hepatic artery and portal vein. This will greatly lessen the bleeding. Upon exposure of a lacerated liver, and after removing clots and loose fragments, there are three choices for the surgeon. (1) He may ligate ducts and vessels, pack the area with omentum, gauze or absorbable hemostatics, or close the laceration with sutures. In large wounds the omentum is better placed against the raw surface than plain gauze. The latter has been extensively used in the past, but in such case the wound becomes infected and it takes many days, or even a few weeks, before the gauze may be safely removed. Absorbable hemostatics should be helpful in some cases. In suturing formerly pieces of muscle or fat were placed in the bite of the needle to prevent cutting the liver. Recently a remodeled autopsy needle and ribbon catgut have been successfully employed.[18] We believe that all liver wounds should be drained to the exterior. Further hemorrhage will thus be detected earlier, and often a bile peritonitis may be prevented.

Spleen. It is our experience that penetrating wounds of the spleen usually involve other organs, such as stomach, kidney, diaphragm or liver, while non-penetrating wounds involve the spleen only. Hemorrhage is often severe, but as in the liver, there may be a lag of a few hours. When this lag extends over several days or weeks, it is referred to as delayed rupture of the spleen. In our last case there was a delay of five weeks. Shock may be severe, and operation is often life-saving. Sufficient blood must be immediately available; we have administered as much as 4,500 cc. in one case. When there is an associated chest wound, we close the latter quickly and then open the abdomen, preferably through a left rectus muscle-splitting incision. For all trauma to the spleen a splenectomy is mandatory.

Pancreas. We have had only two cases of pancreatic injury in civilian practice. One was non-penetrating, being produced in a train wreck by a dinner table edge being shoved against the abdomen. There was accompanying omental and mesenteric hemorrhage as well as extensive hemorrhage and fat necrosis in the pancreas. The patient recovered, but the operation accomplished little. The second case involved a stab wound of the head of the pan-

creas in which bleeding was severe, and the lesser sac filled with clotted blood. Exposure was obtained by dividing the gastrocolic omentum and the wound closed with interrupted cotton sutures. A Penrose drain was inserted to the suture line exiting through the operative wound. The wound later eviscerated and was resutured, followed with recovery of the patient.

Uterus. Rupture of the uterus occurs following caesarian section in about 3 per cent of cases. Another prominent cause of perforation is overvigorous curetting, particularly in a softened uterus or one in which a malignancy exists. Several cases of rupture of the vaginal vault produced by rape or unusual sexual perversion have been recorded at Bellevue Hospital. Symptoms may be entirely lacking or, on the other hand, extremely severe. In all cases in which there is a question of penetration of the peritoneum immediate suprapubic laparotomy should be considered.

SUMMARY

We believe that present world conditions emphasize the importance of the care of the injured. As regards abdominal injuries, we have presented a list of principles and observations, known well to those of this organization, but worth formulating and recording again.

1. Treat shock patients properly. Blood is the principal agent, and sufficient amounts should be available.

2. Remember the possibility of autotransfusion.

3. Bronchial suction will save lives and reduce pulmonary complications.

4. Two-thirds of abdominal injuries with no external signs are serious.

5. Perforations may be caused by the proctoscope, gastroscope, curette and by cancer.

6. Gastric and rectal tubes are diagnostic and reduce drainage into the peritoneal cavity; however, do not irrigate the stomach or rectum when the patient is first seen.

7. A portable x-ray unit is essential.

8. Be alert for free air in the peritoneal cavity.

9. ACTH, blood and antibiotics often mask serious symptoms.

10. Regardless of the ability of the surgeon and optimum operating conditions, a minimum of two hours is consumed in exploratory laparotomy and the subsequent repair procedure.

11. A foreign body should be removed, if practical, at the time of laparotomy, but the operation is primarily to repair the damage created by the object.

12. Test bowel patency with the thumb and index finger after anastomosis.

13. Do not use antibiotics in the abdomen.

14. Colostomies will retract; therefore, leave them long and have them em rge through stab wounds.

15. Remember disruption when closing abdominal wounds.

16. Postoperatively, give nothing by mouth until the patient passes gas from below. (This may occur one to five days postoperatively.)

17. Anticoagulants are impractical in the early care of abdominal injuries.

18. We want to emphasize what has been the experience of the Committee on Trauma of the American College of Surgeons, namely, that in order to administer adequate emergency care to the injured it is essential to make frequent checks on our emergency wards, have frequent meetings of interested members of our hospital staffs and to issue periodic bulletins outlining standard procedures and calling attention to advances in new methods and therapeutic agents.

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NON-PENETRATING ABDOMINAL TRAUMA

WITH SPECIAL REFERENCE TO LESIONS OF THE DUODENUM AND PANCREAS

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THE relative infrequency with which non-penetrating trauma of the abdomen is seen by the individual surgeon in civil practice tends to dull his interest in this field of surgery and, therefore, to maintain the high mortality associated with these lesions. In recent years war casualties with an ample increment of abdominal trauma have, however, focused attention upon this problem, and great improvement in more adequate handling and treatment of abdominal injuries as a result of World War II experience has been made. Application of the methods so successful in war casualties to civilian trauma should markedly reduce the mortality so long recorded and lamented. Recent reports by Welch and Giddings[23] would seem to corroborate this belief.

GENERAL OBSERVATIONS

With the hope of highlighting further present day armamentarium in this field of surgery and the need for its more universal application to the abdominal traumatic casualty, a review of sixty-seven consecutive patients with non-penetrating trauma of the abdomen admitted to St. Lukes Hospital from 1935 to 1951 has been undertaken with special reference to lesions of the duodenum and pancreas.

There were 121,353 total hospital admissions during the sixteen years of this survey of which only sixty-seven represented abdominal trauma (Table 1), an incidence of but one in every 1,800 cases. It will be observed that in injuries to the kidney, spleen and liver the solid-fixed abdominal viscera were found most common.

The over-all mortality in this series was 19.4 per cent. Of the thirteen patients who died all had multiple injuries; six deaths followed operation and seven patients were not operated upon. Of the latter, five were in extremis on admission and died within twelve hours (four within three hours after admission). Two of the patients who were not operated upon died late as a result of unrecognized injury to the spleen and liver which was largely due to other major trauma masking the signs of the abdominal emergency.

Multiple Injuries. There was a total of thirty-six multiple injuries resulting in thirteen deaths (36.1 per cent). This corroborates the reports of many others that the chief element in mortality in abdominal trauma is the association of other major trauma or multiple abdominal injuries. The comatose patients, particularly those with concomitant head injury, present a particularly difficult problem in evaluating an abdominal lesion requiring immediate operation. A high incidence of this combination in any series will contribute materially to post-traumatic mortality. The better use of blood and blood substitutes and antibiotics, operation even in the presence of shock when it is due to hemorrhage, and frequent re-evaluation of the patient should aid in keeping mortality at a minimum in these severe injuries.

The multiple-injured patient, just as the patient admitted soon after injury in whom the indications for operation are not clear, should

TABLE 1
ABDOMINAL TRAUMA—MORTALITY

Location	No.	Deaths	Mortality %
Liver	7	3	42.8
Spleen	18	5 (2 non-operated)	27.8
Kidney	18	0	0
Stomach, pancreas, duodenum	1	1	100
Intestine—duodenum	1	0	0
Jejunum	4	0	0
Ileum	1	0	0
Colon	2	0	0
Bladder	7	1	14.3
Pancreas	3	0	0
Diaphragm	2	2	100
Iliac artery (rupture)	1	1	100
Contusion of abdominal wall	2	0	
Total	67	13	19.4

be kept under vigilant, constant observation with frequent, careful re-examination. This is important since, especially in these patients, fairly rapid early or late change can occur from an apparently inconsequential uncertain primary clinical picture to alarming and characteristic evidence of an abdominal emergency.

Non-operated Cases. There were thirty-four patients upon whom operation was performed and thirty-three without operation. The non-operative patients were divided as follows: contusion or laceration of kidney, eighteen; simple contusion of abdominal wall, four; liver rupture or contusion, four; multiple injuries (thoracic, cerebral and abdominal), five; splenic rupture and multiple fracture, two.

It is invariably with a feeling of chagrin that late unrecognized abdominal hemorrhage is discovered at autopsy. In three of the patients in this series who were not operated upon, concealed hemorrhage was found to be the cause of death. All of these patients were in irreversible shock but lived more than six hours after admission.

Case I. This man had a pneumonectomy for carcinoma two years before injury. He was semi-comatose, quite feeble and dyspneic, and several ribs and his tibia were fractured. In spite of multiple transfusions the patient died in irreversible shock. Metastatic carcinoma was suspected in addition to the obvious fractures, but a ruptured spleen with no evidence of recurrent carcinoma proved lethal.

Case II. This patient had a rupture of the liver, a very extensive crushing injury to the chest and fracture of ten ribs. He died from bile peritonitis and abdominal hemorrhage secondary to rupture of the liver on the second post-traumatic day.

Case III. A delayed, unrecognized rupture of the spleen occurred in a man who had multiple fractures of ribs, laceration of a lung and fracture of a forearm.

Spleen. Nine of the eighteen cases of splenic rupture were associated with multiple injuries of chest, ribs, kidney, liver, skull and extremities. Of these, four survived splenectomy, three died in spite of splenectomy and two were not operated upon.

Nine patients with rupture of the spleen and no associated injury recovered following splenectomy. Four (22 per cent) of the eighteen patients with splenic rupture had delayed hemorrhage; one patient died without operation and the remainder survived splenectomy.

DUODENUM AND PANCREAS

Of particular interest, however, is the relatively high incidence of pancreatic injury and the rupture of the duodenum that proved to be retroperitoneal. These seem worthy of special comment.

Case IV. *Rupture of duodenum—retroperitoneal:* A steel worker, age thirty-two, just after tapping a heat in an open hearth furnace lost his footing and slipped in front of a buggy delivering ore and was crushed between the buggy and furnace. The upper abdomen was caught and squeezed from in front, anteroposteriorly. The patient did not lose consciousness and was brought to the hospital immediately.

On admission he was in severe shock, sweating profusely and complaining of severe upper abdominal pain and nausea. There were small abrasions over the right hip and right abdomen and generalized soreness. No muscular rigidity, abdominal tenderness or peristalsis was present. Blood pressure was 80/30, hemoglobin 14.5 gm. per cent, red blood count 4,500,000, and white blood count 15,300, segments 80 per cent. Hematocrit was 47 per cent, urine negative, blood chlorides 588 mg. per 100 cc., blood protein 7.8 gm. per 100 cc. and CO_2 combining power 60 volume per cent. X-ray flat plate of the abdomen showed gas in the large bowel and no air under the diaphragm, but there was a suggestion of free air along psoas muscle margin. (Fig. 1.)

The patient was given 500 cc. of plasma and a 500 cc. transfusion and morphine sulfate, gr. $\frac{1}{6}$, intravenously. Four hours later he began vomiting foul-smelling brown fluid. Blood pressure was 120/75, pulse 88 and temperature 99°F. He now had extreme abdominal tenderness, with marked rigidity in the upper abdomen, almost board-like. There was still severe steady pain similar to a perforation of a peptic ulcer but peristalsis was absent. Rectal examination was negative and there was no retroperitoneal emphysema in the sacral area. An immediate operation was advised. Laceration or rupture of the intestine was suspected, either of the duodenum or upper jejunum, retroperitoneal.

An upper right rectus muscle-splitting incision was made. Thin, dark, hemorrhagic fluid was seen in the right peritoneal cavity. There was no intraperitoneal perforation or injury to the stomach, duodenum, jejunum, ileum, entire colon and rectum, gallbladder, spleen or liver. There were two retroperitoneal hematomas in the mesentery of the ascending colon. One was in the lower third, 4 cm. in diameter and dark red-brown in color; the other was in the upper third posteriorly, 5 cm. in diameter and dark gray-black in color with marked

FIG. 1. Retroperitoneal rupture of the duodenum; arrow points to retroperitoneal shadow outlining the margin of the psoas fascia.

crepitation over and lateral to it, similar to a subcutaneous emphysema.

The fold of peritoneum lateral to the ascending colon was incised, the colon mobilized and lifted forward and medially, and the crepitant retroperitoneal hematoma explored; a complete transverse retroperitoneal rupture of the duodenum at the junction of the second and third portion of duodenum was visualized. (Fig. 2.) The duodenum was mobilized but the proximal end of the duodenum was not well exposed until the hepatic flexure ligament and lateral margin of gastrocolic omentum were divided. End-to-end restoration of the duodenum was done with interrupted silk serosal sutures and continuous catgut mucosal suture both posteriorly and anteriorly. Posterior silk was inserted with difficulty and reinforced at angles with interrupted silk. A cigarette drain was placed through a lateral stab incision.

Except for a small duodenal fistula the recovery was uneventful with gastric suction, antiobiotics, transfusions and intravenous fluids. Drains were removed on the sixth postoperative day followed with slight duodenal drainage for four days. The fistula closed in five days after drainage sinus was packed. On the fourteenth postoperative day there was one episode of vomiting. The patient was discharged with wound and drainage sinus closed twenty days after the accident.

One year after the accident the patient was symptom-free. There were no dietary restrictions and the patient was eating normally. He had no digestive symptoms and normal bowel evacuations and was back on the same job of heavy work at an open hearth furnace.

OBSERVATIONS

Two years ago before this association Siler gave his timely and comprehensive report on rupture of the duodenum. Having heard his excellent presentation certainly alerted us, when encountering this case, to the possibility of a retroperitoneal rupture of the duodenum being present.

Inasmuch as this type of rupture is not too common it seems worth while to reiterate again some of the characteristic phenomena of this lesion. The important features of our case were as follows: (1) There was a latent period of four hours before characteristic signs of intestinal perforation appeared. (2) A flat plate of the abdomen showed the margin of the right psoas muscle outlined by a gas shadow. This was sufficient to make the x-ray diagnosis retroperitoneal intestinal rupture. (3) There was a retroperitoneal hematoma in the mesentery of the ascending colon, gray-black in color, with

FIG. 2. Complete transverse retroperitoneal rupture of the duodenum; duodenum, ascending colon and hepatic flexure mobilized; gastrocolic omentum divided.

crepitation over and lateral to it. (4) Complete transverse rupture of the duodenum at the junction of second and third portion was present. (5) Complete exposure was not obtained until both the ascending colon and duodenum were mobilized, the hematoma incised and the lateral portion of the gastrocolic omentum divided. (6) Treatment included gastric suction and antibiotics for four days and retroperitoneal drainage. (7) Duodenal fistula occurred after drain was removed and closed in five days following packing. (8) Complete healing was obtained in twenty days.

Incidence. Until Johnson (1944), Sarnoff (1943) and Siler's papers (1949) there has been little if any reference to retroperitoneal rupture of the duodenum in recent years, excepting sporadic cases in foreign literature; thirty-five to forty years ago Miller and Schumacher were able to collect twenty-two and twenty-four cases, respectively. It would seem that the incidence of retroperitoneal duodenal rupture must be greater than this paucity of reports would indicate. Sarnoff and Oremland refer to eighty-four cases found in the literature from 1910 to 1940.

Unquestionably retroperitoneal rupture of the duodenum may accompany other major trauma such as injuries to the pancreas or intraperitoneal rupture of other viscera and its identity may thus be overshadowed or lost.

Symptoms and Signs. There may be a latent period following injury before symptoms and signs of actual perforation or rupture appear. However, there is usually some type of *persistent* pain and *repeated* vomiting. Pain at times may be referred to the lower right abdomen or even the left shoulder or left abdomen.[4,15] With extensive laceration increasing pain, abdominal rigidity and tenderness will eventually appear.

Aid to Diagnosis. A flat plate of the abdomen is particularly helpful. Evidence of retroperitoneal gas either subdiaphragmatic (small bubbles) or about the right kidney, along the psoas muscle or presacral, have been described (Siler, Sperling and Rigler).

Small duodenal retroperitoneal ruptures have

been reported in which the first evidence of major injury is the late development of a retroperitoneal abscess often in the right lower abdomen, exploring of which shows the origin to be from a small duodenal tear.

In a doubtful case the duodenum with its rupture may be visualized by a swallow of lipiodol or thin barium. Lateral or oblique views should be particularly valuable (Siler).

At times the differentiation between a duodenal rupture and trauma to the pancreas or traumatic pancreatitis may be difficult. Wapshaw[21] believes that repeated determination of the serum amylase should be helpful. He states that in pancreatitis or trauma to the pancreas serum amylase is highest in the first few hours and tends to decrease each day; while in perforated ulcer or rupture of the duodenum serum amylase will tend to rise each day of untreated rupture or perforation.

Operation. At operation the combination of an apparent retroperitoneal hematoma in the base of the mesentery of the ascending colon with retroperitoneal crepitation should immediately suggest retroperitoneal rupture of duodenum. Also discoloration and edema of the upper right posterior peritoneum, particularly if bile-stained, green or yellow-brown, may be considered pathognomonic. A peculiar color to the hematoma such as gray-black should demand investigation by incision. If the posterior peritoneum is also torn, bile-stained intraperitoneal fluid should arouse suspicion.

PANCREATIC TRAUMA

Three of these cases were *isolated* instances of pancreatic trauma. One was a *complete* rupture of the pancreas associated with rupture of stomach and duodenum.

CASE V. On March 15, 1943, twenty-nine hours before admission, a nineteen year old male while at work was struck by an iron bar across the right lower thorax and abdomen. Immediate steady pain in the abdomen about the umbilicus with persistant vomiting and pain from constipation increased in intensity and became worse on breathing. The patient was pale and dehydrated with knees drawn up on abdomen. The abdomen was scaphoid with extreme superficial tenderness and rigidity in the upper right quadrant. Peristalsis was absent. Flat x-ray plate of the abdomen was normal. Red blood count was 4,800,000, white blood count 15,000, hemoglobin 13 gm. per cent and urine albumin 1+.

The patient was relieved in part by local novocain injections, gastric suction and intravenous fluids. There was occult blood in stool, coffee-ground gastric drainage. The patient had a mild febrile course. Six days after admission a smooth mass was observed in the right upper abdomen 6 cm. in diameter. Tenderness was gone and there was no further pain. Vomiting occurred with gastric suction tube clamped; exploratory laparotomy seemed indicated.

At operation, a rather large retroperitoneal hematoma was found along the posterior margin of the head of the pancreas and seemed within its capsule and beneath the duodenum in its distal half. The duodenum formed a part of the anterior wall of the hematoma which was 15 cm. long and 6 cm. in diameter. (Fig. 3.) There was no rupture of the duodenum. The duodenum was mobilized and the hematoma exposed from behind. A quantity of clot and about 300 cc. of fluid was evacuated and the area drained posteriorly by three cigarette drains. Recovery was slow, with intermittent persistent vomiting. The stomach continued to be dilated with overactive visible waves of peristalsis which were not relieved by constant gastric suction. One month after the hematoma was drained a posterior gastroenterostomy was done with jejunostomy for feeding. Both the stomach and duodenum were found dilated down to the junction of the duodenum with the jejunum, but there was no mechanical obstruction at this area.

Excellent and prompt recovery was obtained in one week, and the patient retained frequent feedings well. The jejunostomy tube was removed in two weeks. Four weeks after gastroenterostomy the patient was discharged. The wounds all healed well, also the drainage tract. The patient was eating well.

Within one week the patient was readmitted to the hospital because of recurrent upper right abdominal pain with vomiting and coughing; chest x-ray was normal. The patient was relieved by sedative and diet. Three weeks later, however, severe abdominal upper right quadrant pain, intermittent and severe, with chills and sweating occurred again. A palpable mass the size of a lemon was seen at the right costal margin. Icterus index was 12, red blood count 3,500,000, white blood count 19,000, segments 88 per cent, hemoglobin 12.5 gm. per cent, temperature 101°F., pulse 128 and respiration 26.

There seemed every likelihood that an acute suppurative cholecystitis had developed, secondary to former trauma of the pancreas, and an operation was indicated. At operation a long distended suppurating gallbladder without stones was found with fibrinous exudate over its anterior wall and densely adherent to the common duct. Culture of gallbladder contents showed Bacillus proteus. Cholecystectomy was performed.

FIG. 3. Large hematoma of pancreas posteriorly.

Convalescence was uneventful, and the patient was discharged in two weeks with wound well healed and drainage sinus about closed. He returned in two days because of vomiting of blood with severe upper right quadrant pain. Red blood count was 3,100,000 and hemoglobin 9 cm. per cent. The patient responded well to transfusions and frequent feedings. He was placed on a bland diet. Three weeks later, however, he had a mild attack of infectious hepatitis with prompt recovery in four weeks.

During the next six years the patient was admitted to hospital twice, with a history of recurrent severe epigastric pain with vomiting at long intervals relieved promptly by gastric suction.

Finally, on November 5, 1950, he again was admitted for study because of severe attacks of upper right abdominal pain with vomiting occurring about six to eight weeks apart. X-ray study showed an excellent functioning and patent gastroenterostomy stoma and no evidence of ulcer; but there was still a large atonic and dilated duodenum with six-hour retention and a marked partial obstruction at the duodenojejunal junction. There was no apparent mechanical explanation for overdistension. Apparently pain and vomiting were caused by overeating, inadequate gastric drainage by gastroenterostomy and rapid filling of the duodenum because of obstruction. An operation was advised and subtotal gastrectomy contemplated. However, at exploration on November 3, 1950, when the gastroenterostomy stoma and entire stomach showed no abnormality and the duodenum and pylorus were found to be hugely dilated, a take down of the gastroenterostomy seemed all that was necessary with a duodenojejunostomy to relieve the obstruction at the duodenojejunal junction. This was done fairly readily. The appendix was also removed as it showed obstruction from two concretions. The patient made a rapid recovery from the operation.

One year later the patient had been back at work ten months. He had no further vomiting or distress after eating. Occasionally, however, slight pain in the upper left abdomen occurred. The patient has gained no weight but feels stronger than at any time in his life.

Comment. It is interesting to speculate why after a severe contusion and hematoma of the head of the pancreas acute suppuration of the gallbladder and obstruction at the duodenojejunal junction occurred. It is possible that reflux of pancreatic fluid up the common duct and

FIG. 4. Pressure deformity of the greater curvature of the stomach caused by large pancreatic cyst.

into the gallbladder might have been a factor in the development of the gallbladder suppuration and a marked disturbance of the vagal innervation of the duodenum; or interference with its nervous mechanism as a result of the original trauma may have contributed to the atony and apparent partial obstruction at the duodenojejunal level.

CASE VI. A fifty-four year old woman was admitted on May 21, 1944, complaining of pain and a mass in the upper left abdomen. Ten years before she fell and struck her left side against the side of a bathtub. Two to three months later she noticed a lump in the upper left abdomen at the area of injury which has been present ever since. For the last eight years there has been a slow increase in its size. With the onset of the tumor the patient had sharp and lancinating pain in the left upper abdomen radiating to the umbilicus. The pain gradually subsided but the tumor persisted. For the last two years there has not been much change in its size, but the patient has had a frequent, dull ache in her left side.

Four days before admission she had a sudden, severe epigastric pain with difficult respiration which subsided in a few hours. She had had a similar attack seven years before. There was no vomiting, loss of weight or jaundice.

Physical examination revealed a very obese woman. Examination of the head, neck, heart and lungs was essentially normal. There was an easily palpable mass definitely cystic in the upper left abdomen which was smooth but not tender. It extended from beneath the left costal margin to the midline in the epigastrium down to the level of the umbilicus and then far into left flank. The left lateral abdominal veins were prominent. X-ray showed a large mass in the upper left abdomen pushing the stomach to the right (Fig. 4) and poor concentration by the gallbladder. Basal metabolism rate was +8. Blood sugar was 92 mg. per cent, blood urea 10 mg. per cent, red blood count 4,000,000, white blood count 8,000, hemoglobin 12 gm. and platelets 340,000 per cu. mm.

The diagnosis, therefore, was a pancreatic cyst and gallbladder disease. At operation on May 26, 1944, a large cyst was found involving the left half of the pancreas about the size of a football, broad, with a deep attachment to pancreas. It contained 5,000 cc. of thin, turbid, pale brown fluid in which no amylase or trypsin was detected. The gallblad-

FIG. 5. Recurrent pseudocyst of the pancreas.

der was a little thicker than normal but contained no stones and collapsed easily on pressure. There was no other intraperitoneal abnormality. The cyst was marsupialized. Resection in an obese women seemed contra-indicated. The cyst was brought up through the gastrocolic omentum into a left rectus incision and packed with gauze. Recovery was uneventful. All gauze was removed in three weeks and the sinus into the cyst closed rapidly and healed well.

Six months later, October, 1944, the sinus was well healed but a ventral hernia was beginning. The area of the cyst was palpable as a hard scar 6 by 1½ cm. On April 4, 1945, postoperative ventral hernia was repaired. A small sinus into the cyst was excised and closed. Remnant of the cyst scar was 5 to 6 cm. in diameter. The wound healed firmly. Five years later, February 21, 1950, cholecystectomy for cholelithiasis and subacute cholecystitis was performed. Common duct was explored and found normal. Remnant of pancreatic cyst was 6 by 2 cm., hard scar, no cyst apparent. Recovery was uneventful.

The patient was readmitted on June 1, 1951, fifteen months later, having had pain in left upper abdomen for the last six months. A mass had been present four months which has gradually increased in size.

This mass was in the upper left abdomen, cystic and 25 cm. in diameter extending to the level of the umbilicus. The patient was still markedly obese. At operation a large recurrent pancreatic cyst was found involving the tail and middle third and extending over to the head containing about 4,000 cc. of turbid brown fluid; thick vascular wall. (Fig. 5.) There was no evidence of malignancy. Again conservative surgery seemed advisable, therefore, after aspiration cyst jejunostomy was done, retrocolic by Roux Y type of anastomosis through the mesentery of transverse colon. (Fig. 6.) Recovery was uneventful with firm healing of the wound. Four months later, October, 1951, there was no recurrence of cyst or pain. The patient was eating well and bowel evacuations were normal.

FIG. 6. Cyst jejunostomy, retrocolic Roux Y type; end of distal jejunum closed; lateral anastomosis between cyst wall and the side of the jejunum.

CASE VII. A nineteen year old man was admitted on January 10, 1940, complaining of abdominal pain and burns of lower extremities. One hour previously while working as a brick layer at a coke oven he was struck in the abdomen by a door car and thrown into a bed of hot coke; his clothing caught fire. Pulse was 160 and blood pressure 104/66. The patient was found to have a fracture of the seventh rib in right axilla and right pneumothorax. There was moderate tenderness in the epigastrium, no great rigidity and very extensive second and third degree burns of both lower extremities. Mild trauma to liver was suspected.

Hemoglobin was 13 gm. per cent, red blood count 4,800,000, white blood count 16,000 and urine negative.

Under conservative management and tannic acid treatment of burns there was a gradual improvement and spontaneous absorption of pneumothorax, with a low grade septic course. The patient had nausea and vomiting for three days, epigastric pain subsided in six days. At the end of the first week he had diarrhea for two days. The burns on his left leg required skin grafting, and in two and a half months the burns were practically healed. Recovery was complete with no evidence of jaundice or diaphragmatic injury. On March 21, 1940, the patient was discharged. He was readmitted, however, on April 25, 1940, three and a half months after injury, complaining of epigastric pain ever

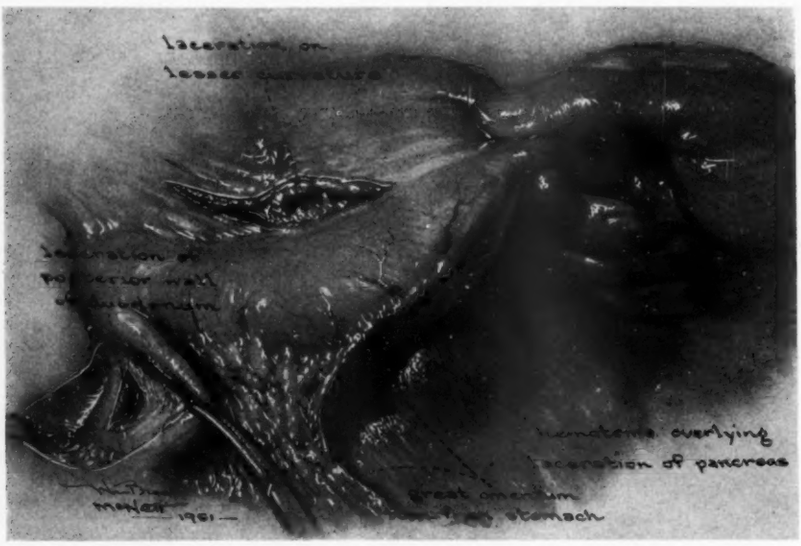

FIG. 7. Rupture of the stomach; retroperitoneal rupture of the duodenum; complete laceration of the pancreas with retroperitoneal hematoma.

since discharge from hospital. The pain had been fairly constant but with sharp exacerbations at irregular intervals and no vomiting; it had no relation to food intake. The patient noticed an abdominal mass for one week; bowel evacuations were normal.

The patient had good color, no jaundice and was well nourished. There was a smooth, firm swelling below the right costal margin and extending to the midline four fingerbreadths below ensiform cartilage, slightly tender, giving the appearance of an enlarged liver or a hematoma, associated with scars of burns of thighs and legs which were well healed. Hemoglobin was 13 gm. per cent, red blood count 5,400,000 and white blood count 12,000. Prothrombin time was 83 per cent of normal. Gastrointestinal study showed a large pressure defect pushing the stomach anteriorly. Retroperitoneal hematoma or cyst was suspected. At operation on April 27, 1940, a large cyst behind the stomach was found apparently arising from the right half of the pancreas extending well over into the left half. It contained 500 cc. of thin brown-colored fluid showing very active amylase and a weak trypsin action. Marsupialization of cyst was done and two tube drains inserted; recovery was uneventful and drains were removed in fifteen days. Drainage ceased in twenty-five days and sinus healed in thirty-five days. The patient was back to work in two months.

On October 1, 1951, eleven years later, the patient had remained completely well and was working regularly. There was no evidence of recurrence and the wound was well healed. He had gained 50 pounds in weight.

CASE VIII. A forty-two year old man was admitted with intense pain in the epigastrium. He had had a huge steak dinner with ample alcoholic accompaniment, felt sleepy and went into a garage to sleep. The owner of the garage apparently unaware of sleeping inebriate, backed his car into the garage, the car passing over the patient and pinning him against the wall of the garage. On admission the patient was writhing with abdominal pain and had extreme rigidity and tenderness of abdomen. Pulse was 120 and blood pressure 115/75. There were small abrasions of face and neck, contusion and multiple fractures of ribs of left lower thorax. Extreme tenderness and rigidity of entire abdomen was present which was worse in the epigastrium. White blood count was 19,900. Flat plate of the abdomen showed free gas in the subdiaphragmatic area.

Perforation of an abdominal viscus seemed obvious. Immediate operation revealed a huge rent in the anterior wall of the stomach (pars media) 5 cm. in diameter with another parallel tear of serosa 8 cm. long. The entire peritoneal cavity was filled with huge amounts of food particles and bloody fluid, 5,000 cc. Gastrocolic omentum was torn free from two-thirds of the greater curve of the stomach. The peritoneal cavity was aspirated and as much of the food particles removed as possible. Bleeding vessels of gastrocolic omentum were ligated. Rent in the stomach was closed with three layers of sutures and subdiaphragmatic space on the left thoroughly drained.

The patient failed to respond to transfusions or intravenous fluids. He died twelve hours after operation.

At autopsy in addition to multiple fractures of ribs and recently sutured laceration of stomach and general diffuse peritonitis, a retroperitoneal laceration of the duodenum 4 cm. from the pylorus, 1.5 cm. in diameter, and a complete laceration of

the pancreas between middle and left lateral thirds were found, with large retroperitoneal hematoma and an intramedullary hematoma of left adrenal. (Fig. 7.)

Comment. There was no rent in the posterior peritoneum and, therefore, lesion of the duodenum and pancreas in addition to rupture of the stomach was not suspected, although retroperitoneal hematomas were observed. However, the patient apparently died of acute massive general peritonitis from intense and diffuse contamination of peritoneum by food particles.

The question, therefore, might properly be raised whether or not all retroperitoneal hematomas should be treated conservatively. Certainly it would seem advisable that those hematomas found at operation in the region of the pancreas or duodenum should be explored for evidence of laceration or rupture involving these organs.

OBSERVATIONS ON PANCREATIC TRAUMA

Of these four cases of pancreatic trauma, one patient had a large hematoma of the head of the pancreas, two had pancreatic cysts that followed mild abdominal trauma and one was a case of complete laceration of the pancreas associated with rupture of the stomach and duodenum. The first three patients survived surgical treatment and are in good health at present. The fourth patient died with concomitant rupture of the stomach, the major injury, within twelve to fourteen hours in spite of suture of the rupture of the stomach, but with no direct treatment of the pancreatic lesion.

Pathology. Lesions of the pancreas, the result of subcutaneous injury, therefore, may be either simple contusion with hematoma, lacerations of the gland of varying degrees, or complete rupture. There may be concomitant trauma particularly to the stomach and duodenum. Minor lacerations or extensive contusions may be followed with the development of pseudocysts. Keynes makes the following statements: (1) rupture of the pancreas is uncommon, unassociated with other injuries, and when associated with concomitant trauma the victim is not likely to survive; (2) very few cases have been treated successfully surgically; (3) drainage of the lacerated pancreas may be followed with pancreatic fistula.

Aldis' explanation of the formation of pseudocysts seems plausible. He believes that hematoma or contusion of the pancreas with trauma of pancreatic cells releases pancreatic ferments. Digestion of clot and pancreatic tissue follows, with fat necrosis and further hemorrhage. With repeated digestion the pancreatic duct may eventually be involved and with release of pancreatic fluid thus permitted, a pseudocyst may then develop. With extensive laceration of the pancreas involving the duct there will be rapid collection of pancreatic fluid in lesser peritoneum or retroperitoneal tissues. Aldis holds that the chief complications of pancreatic trauma are, therefore, the formation of pseudocysts; and often when these are drained, fistula may result. The rapidity with which pseudocysts increase in size and the persistence of fistulas depend upon the extent of involvement of or obstruction in the main pancreatic duct.

In one of Keynes' cases of pancreatic fistula, obstruction of the duct was beautifully demonstrated by lipiodol injection of the fistula.

Symptoms. In extensive injury in addition to evidence of intra-abdominal visceral rupture, shock, severe pain, abdominal rigidity and fulness (lesser peritoneal effusion) and pain in the left shoulder have been described.[2]

However, in mild or simple trauma early symptoms are vague and indeterminate until palpable hematoma or cyst occurs, but frequent and repeated vomiting with persistent pain is likely to be present. Aldis refers to mild shock and abdominal pain with vomiting 10 to 14 days following trauma, occurring in a patient apparently recovering from mild abdominal trauma, as indicative of further hemorrhage into an original hematoma of pancreas and should suggest the onset of a pseudo-pancreatic cyst. Persistent pain with exacerbations of marked severity occurred in both our cases of pancreatic cyst.

Diagnosis. (1) Actual diagnosis of a pancreatic injury in mild abdominal trauma may be difficult unless the blood amylase is elevated. The routine determination of blood amylase concentration in doubtful abdominal injury may serve to detect those in which the pancreas is involved.[11] Again Wapshaw's differentiation between duodenal and pancreatic lesions by amylase determinations may be helpful.

In extensive laceration an abdominal emergency will be evident; unless blood amylase is elevated, actual diagnosis can be made only at operation. If great abdominal fulness of rapid

onset persisting after gastric suction is present, lesser peritoneal effusion and pancreatic rupture may be suspected.

(2) Eventual hematoma or cyst may not be determined until the cyst or hematoma is palpable, and gastric duodenal x-ray shows position of extra gastric or extra duodenal mass or shadow.

Complications. While pseudocyst and pancreatic fistula following drainage or marsupialization of cyst have long been recognized as not infrequent complications of pancreatic trauma, in view of the sequelae in Case IV with hematoma of head of pancreas, the question may be raised whether or not atonic obstruction of the duodenum (vagal paralysis) and secondary suppuration of gallbladder should not be added to the potential abnormalities or complications that may follow pancreatic injury.

Treatment. (1) In extensive laceration or rupture immediate laparotomy is indicated, with concomitant treatment for shock. Control of hemorrhage and drainage of the traumatized pancreas should in general suffice. Suture of the posterior capsule may be considered in complete rupture. Reuniting a severed main pancreatic duct would be ideal, but would rarely seem feasible or advisable with extensive pancreatic trauma and in most instances technically impossible.

(2) For minor injury conservative treatment should suffice until evidence of hematoma or cyst appears. Hematoma, if large, should be drained. Pseudocysts may be excised, drained internally or marsupialized.

While excision of the cyst with or without a portion of the pancreas is preferable, particularly since unsuspected carcinoma has been reported in a few excised cysts,[3] in the poor risk patient or in cases in which the extent of the cyst would require a resection of sufficient magnitude to suggest a prohibitive mortality, cyst gastrostomy or cyst jejunostomy seems to be proving eminently satisfactory and is attended by a low mortality.

Marsupialization, while a satisfactory temporary expedient and attended often by apparent cure, does not guarantee against late recurrence of cyst (Case V) and should be either abandoned in favor of direct cyst anastomosis to bowel or stomach, or reserved for the very poor risk patient. The cause of cyst recurrence after marsupialization is probably a persisting partial obstruction of the main pancreatic duct. Since the presence of this obstruction can seldom be determined preoperatively or even at operation and since recurrence of cysts with fistula may follow marsupialization,[2] marsupialization cannot be regarded as a therapeutic procedure which assures a cure of the cyst even when healing of the postoperative sinus occurs.

Mortality. The mortality following rupture of the pancreas in association with other injuries is exceedingly high;[2,7] even for isolated rupture of the pancreas, when other than minor, the mortality is not low. Morguot and Constantini reviewed thirty cases of rupture of pancreas in the literature up to 1923. Of the twenty-one patients treated surgically, five died (24 per cent); the nine patients not operated upon all died.

The mortality of minor injury of the pancreas is the mortality of its complications, hematoma, pseudocysts and pancreatic fistula, secondary hemorrhage and gallbladder or duodenal involvement.

SUMMARY

1. A series of sixty-seven cases of non-penetrating trauma of the abdomen has been reviewed with over-all mortality of 19.4 per cent.

2. Occurrence of subcutaneous abdominal trauma is relatively rare in hospital admissions. Injury to the liver, spleen, kidney and the fixed solid viscera are most common.

3. The high mortality lies in the frequency of multiple concomitant injuries not only intra-abdominal but also those of the head, chest and diaphragm and pelvis. Lesions of the liver, spleen, stomach and diaphragm show the highest mortality.

4. There were thirty-four operative and thirty-three non-operative cases. The non-operative cases were largely those of mild trauma, contusion of the kidney, those in extremis and those with delayed or concealed hemorrhage in the multiple-injured.

5. Nine of the eighteen cases of splenic rupture were associated with multiple injuries; four survived splenectomy. All patients in whom splenic laceration was the only trauma recovered following splenectomy.

6. A case of retroperitoneal complete rupture of the duodenum between the second and third portions is reported. The diagnosis was aided by gas outlining the psoas muscle shadow, demonstrated in flat abdominal x-ray. Likewise, retroperitoneal crepitation lateral to a peculiar

gray-black hematoma in mesentery of the ascending colon was present. For full exposure of ruptured segments not only mobilization of the ascending colon and duodenum, but also division of lateral margin of the gastrocolic omentum was required.

7. The reported characteristics of retroperitoneal duodenal rupture are reviewed.

8. The relatively high incidence of pancreatic lesions in this series is noteworthy. These consisted of a case of complete rupture of the pancreas with rupture of stomach and duodenum, a simple contusion of the head of the pancreas complicated by secondary suppuration of gallbladder and atonic obstruction of duodenum, and two cases of mild pancreatic trauma followed with the development of pseudocysts.

9. The high mortality of pancreatic lesions with concomitant major trauma is discussed.

10. The complications of pancreatic injury are reviewed, particularly pseudocyst and fistula, and their treatment described. For pseudocyst resection with partial pancreatectomy, cyst gastrostomy or cyst enterostomy is the treatment of choice.

CONCLUSIONS

1. Until full and more general use of modern therapy consisting of multiple simultaneous transfusions, arterial transfusion and the better treatment of shock and antibiotics, a high mortality from non-penetrating abdominal trauma can be anticipated particularly in the patient with multiple major injury.

2. With multiple concomitant injury particularly in the comatose patient, evidence of an abdominal emergency may be difficult to evaluate.

3. Constant supervision of the critically ill patient with repeated thorough abdominal examination at fifteen to thirty minute intervals is imperative. Particularly with patients in shock latent intervals of indeterminate signs may rapidly change to characteristic evidence of acute abdominal lesion as improvement from treatment takes place.

4. Retroperitoneal rupture of the duodenum may be suspected when, with symptoms and signs of abdominal perforation, gas can be demonstrated to outline the right psoas muscle or to be present as multiple small globules in the retroperitoneal tissues or about the right kidney.

5. At operation crepitation beneath the right upper posterior peritoneum, a yellow or yellow-brown discoloration of this peritoneum or a peculiar colored (gray-black or bile-stained) hematoma in the ascending colon mesentery, should raise suspicion of a retroperitoneal rupture of the duodenum. If the posterior peritoneum is torn, the peritoneal fluid may be bile-stained.

6. Not only mobilization of duodenum and colon but also division of gastrocolic omentum may be necessary for full exposure of ruptures involving distal half of the duodenum.

7. Lesions of the pancreas from a non-penetrating trauma may be either contusion, laceration or complete rupture. They are not infrequently accompanied by other major intra-abdominal trauma and have a high mortality.

8. Mild trauma or contusion of the pancreas may result in hematoma and be complicated by the development of pseudocysts. Persistent pain after mild abdominal trauma should suggest possibility of pancreatic lesion and the likelihood of a pancreatic cyst appearing.

9. Hematoma of the head of the pancreas may have associated complications involving gallbladder and duodenum.

10. Treatment of pseudocysts of pancreas resulting from trauma may be complicated by pancreatic fistula when partial or complete obstruction of the main pancreatic duct is present. Hence excision of the cyst with or without partial pancreatectomy, cyst gastrostomy or cyst jejunostomy is the treatment of choice.

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DISCUSSION OF PAPERS BY DRS. POWERS, MATHEWSON AND HALTER, CAMERON AND SYKES, PATTERSON AND BROMBERG, AND ESTES, BOWMAN AND MEILICKE

PHILIP D. ALLEN (New York, N. Y.): I wish to discuss Dr. Patterson's paper but in passing I cannot help but comment on the work of my good friend, Dr. Powers, from Cooperstown. His very efficient institution serves the area of my farm and I might say that even styles in trauma change as the years go by. In the old days in the country impalement on a pitchfork handle was a very common injury—sliding off a load of hay, not knowing that a pitchfork was standing beside the wagon. Now they bale the hay and do not use pitchforks. They use hooks and these hooks produce serious injuries to the soft tissues of hand and forearm.

Dr. Patterson spoke about the standardizing of procedures in the handling of emergency traumatic cases, and a certain amount of that is certainly necessary. There is only one danger. One of my former chiefs used to say that he was always afraid to standardize things too much for fear of standardizing mediocrity. However, certain rules have to be laid down for the resident staff to follow.

I think without a doubt that the most important thing to the person who sees these cases first is some attempt at an accurate diagnosis. I cannot help but believe that sometimes we attempt to treat the shock too long without an attempt to get busy and operate and cure the primary cause of the shock. The two things can be done simultaneously more often than is followed out, I fear.

The resident staff today in most hospitals—and I think it is a pretty common complaint—have a great tendency to get x-rays immediately and get hematocrits immediately, and all the laboratory data, none of which certainly can be decried; however, they forget to do a little palpating and a little auscultation. It was my privilege for some years to serve under Dr. Ellsworth Elliott who was a master of diagnosis by use of a hand and the stethoscope on the abdomen. He would sit down beside a patient and, with his massive hand, very lightly palpate the abdomen, going over it and over it, and each time around bearing in a little deeper. After four or five minutes of this, or maybe longer, in which you were wondering if maybe he had gone to sleep, he would come up with some pretty accurate diagnoses. With the young fellows today, however, that is the last thing they do.

Dr. Devine's suction tube or something of that sort would, I think, be a great asset in the handling of most of these cases. Some of these patients come in after a full meal, we operate on them, forget to get the stomach cleaned out and have a big anesthetic problem as a result of a full stomach.

Just as another trauma that may result in abdominal problems, I would like to mention one case we had on our service some few months ago. A young woman came in on a Sunday morning with a history of sudden severe abdominal pain in the lower abdomen which occurred four or five hours previously. It was a very, very severe pain and caused her to seek medical aid immediately.

She was brought to the hospital with slight elevation of temperature, an elevated blood count and a rigid abdomen. It was pretty difficult to define a mass but the consensus was that there was a mass in the lower portion of the abdomen just to the right of the midline.

The patient was opened with a tentative diagnosis of a ruptured ovarian cyst although no mass could be felt on pelvic examination. What was encountered was a massive hematoma in the abdominal wall as the result of a rupture of the inferior epigastric artery. On later quizzing the patient stated that this sudden severe pain had its onset when she was having intercourse. Upon looking it up, we found that it has been reported. It is an unusual trauma but does happen.

CAMPBELL GARDNER (Montreal, Can.): During the war when we had 82,000 patients pass through No. 1 General Hospital we had no cases of gas gangrene develop because we left our wounds open, I think. Since we have been back home, where we are inclined to sew wounds up, we have had four. In one case it necessitated the amputation of a forearm. I wonder if we are safe in suggesting, particularly to our younger surgeons, that we can close wounds with impunity.

Secondly, although I entirely concur with the idea that if a person has been well prepared beforehand by means of the antibiotics, it is probably relatively safe to avoid colostomy, I am afraid that, if I had to deal with such a case without any preparation, I would like to form a colostomy for a few days just to be sure that peritonitis does not develop. I do not know whether that is a general belief. I realize that my orthopedic friends at the present time are able to do all sorts of things, close wounds immediately and the like, and that the old ideas of World War II are rapidly disappearing, but I would like to sound a tiny note of caution.

GROVER C. PENBERTHY (Detroit, Mich): It was my privilege to have the opportunity of reviewing Dr. Estes paper and I am sorry that he is not here to present that data. His paper consisted of a sixteen-year study and, in that period of time, he calls attention to the low incidence of the non-penetrating abdominal injuries in their clinic. It was 1 to 1,800 and he thought because of the fact that that type of injury is so rare, it may in many instances be overlooked and that the seriousness of the condition may be overlooked. He tried to emphasize the need for early attention, as has been mentioned by several, and also emphasize the importance of the follow-up and watching the patient.

In the diagnosis of injuries in ruptures of the duodenum Dr. Johnston has called attention to a very outstanding diagnostic point, and I am sure you have all recognized that in injuries, lacerations of the duodenum, the x-ray flat plate will show multiple vesicles of air which, of course, are in the recesses of the retroperitoneal space. That is an important sign and Dr. Estes also called attention to the need for early diagnosis in the care of any of the injuries that pertain to the viscera of the abdomen.

The matter of the care of the pancreas that has been traumatized and eventually goes on to form a pseudocyst was taken care of very nicely by Dr. Halter. He really emphasized some of the points that Dr. Estes wished to bring out.

In general I think what Dr. Estes wished to project to this organization was the need for early diagnosis, as has been emphasized by Dr. Russel Patterson, and the close and thorough follow-up. Instead of the individual being admitted to the hospital and allowed to remain for some time without attention, he thinks—and we all agree with him—that that type of case in which there is nothing on the surface to call attention to injury within the abdomen requires special attention. One can recognize the fracture by the evidence of trauma, external trauma of the extremity, but the abdomen is quite a different picture from the standpoint of the need for careful survey.

I am glad Dr. Allen mentioned Dr. Ellsworth Elliott's big hand. It is true he did have a big hand, and the point he emphasized in the careful palpation of the abdomen is something that we must, as always, bear in mind. The x-ray is a great help; there is no question about that. However, there are other physical findings that can be recognized and if recognized early, I am sure, as Dr. Estes tried to point out, our mortality will be low.

LAURIE H. MCKIM (Montreal, Can.): One cause of pentrating wounds into the pouch of Douglas that I did not hear mentioned is the injudicious use of the rectal tube by the nurse. It has been my unfortunate experience to see post mortems on these patients, one during my intern days and another in a casualty clearing station in 1918. I do not know whether it is quite as common as it used to be, but so many of our graduate nurses taking care of a patient think nothing of ramming the rectal tube in just as casually as you like. I do not know how universal the practice is in your country but I consider it an extremely dangerous one.

It has also been my unfortunate experience to see two cases of perforation of the large bowel by sigmoidoscopic examination. One was into the pouch of Douglas and the other was about the lower third of the sigmoid. I may say that both of these cases were done with the patient under anesthetic; a procedure which I am always very chary about. One of these I repaired myself, the perforation of the sigmoid. It was about twenty years ago. I was called in to see it about six hours after it was done. The patient had been prepared for hemorrhoidectomy and, consequently, the bowel was clean. There was very little soiling of the peritoneum and I closed the perforation and drained the abdomen. There was an uneventful recovery. I am quite sure that if I were doing the same thing now I might follow the advice that has been given and do a colostomy.

HARRY E. MOCK (Chicago, Ill.): Someone mentioned the delayed hemorrhage in some of these injuries. I think it is exceedingly important to remember that after an abdominal injury, giving no symptoms, sometimes as long as six weeks as reported years ago by Ferguson of Chicago, delayed hemorrhage of the spleen may occur. I have had two cases of these delayed hemorrhages. One case covers a picture of pancreatitis and the other one makes me wonder to this day if the patient

didn't have traumatic pancreatitis along with a ruptured liver.

In the first case the man was brought into the Evanston Hospital where I saw him a few hours later in consultation. He was wild, screaming, laughing, and carrying on like an exceedingly drunk individual. From examination of the abdomen we made a diagnosis. Incidentally, that night he had been to a Yale banquet and came home to Barrington about two o'clock. His wife heard him get out of bed and go into the bathroom; she heard a fall and went in, thinking the boy was drunk again. The local doctor was called, who also thought the patient drank too much. Later the next morning he was brought to the hospital because of this excessive delirium, and our diagnosis was perforation of gastric ulcer and we operated.

What I found was a belly full of blood which came from a complete tear of the splenic artery. There was no tear in the spleen. The nurse said at this stage that the man was dying; we had to quit, stop the hemorrhage. I put clamps on the torn splenic artery and got out. The patient died three days later following a gas bacillus infection where it bubbled out of the drainage tube, and cultures blew the cork of the container within about eight hours.

I removed my clamps after three days and the patient died the following day. Autopsy showed thrombosis of the vessels, with involvement of the pancreas. There was no tear in the pancreas. I felt that the thrombosis probably traveled back from my clamps, but he had the picture of an acute hemorrhagic pancreatitis and his hyperinsulinism, so well described by Graham in these tumors of the pancreas, carried out the picture Graham gave of those wildly delirious, screaming then laughing, yelling, drunk individuals with that condition.

In the other case I was called to Rockford, Illinois, three weeks after a boy has fallen from a haymow, lit on the end of a 2 by 4 on the abdomen, and had been treated conservatively all of that time, yet he had had periods of wildness. I operated and found three tears in the liver, very large tears, and two days after the operation was called back because the boy had gone into one of these very wild states. When they told me what the trouble was, as I entered the hospital, his mother said, "Can't you hear him yelling?" We could hear him clear down at the entrance. I told her to go across the street to the grocery store and get some candy and bring it back. Shortly after he sucked this candy, while we were making the diagnosis, his wild delirium stopped.

Those are two points I think we ought to remember in the diagnosis of pancreatitis.

Robert H. Kennedy (New York, N. Y.): I felt I could not let this group of papers pass without stressing something that has been brought home to me hard in the last few years. Several of the speakers mentioned the matter of non-penetrating injuries of the abdomen. We know that the majority of the non-penetrating injuries of the abdomen are multiple injuries. We know at the present time, as Dr. Griswold brought out, we are putting cases more and more into individual special groups and oftentimes the men do not have the benefit of seeing all types of lesions.

A year and a half ago in helping with the American Board of Surgery clinical examinations a man came before us to discuss a case of fracture of the pelvis and rupture of the bladder. It was evident that he knew nothing about either the fracture of the pelvis or the ruptured bladder. He was, I believe, the best-trained candidate that we had that morning; and when we had delved into this quite strenously and found that he could almost invariably give the wrong answer, we asked him some questions about subtotal gastrectomy and things like that and found he had everything down perfectly. I could not resist the temptation of asking what his previous experience had been.

I found that he was a graduate of one of our best university hospitals. When asked if they had an ambulance service, he said they had a large one; he had been there five years.

"As a resident for five years, how many fractures did you see in that time?"

"I never saw one."

"In those five years how many urologic cases did you see?"

"I never saw one."

"Are the answers you have been trying to give us what you remember from your medical school training in fractures and in urology before you ever had an internship?"

"That is right, sir; I have never thought of these problems since."

"Where would such a case go in your hospital?"

"It would go to the orthopedic section."

"What would happen to the injury of the bladder?"

"The urologist would be called in consultation, probably on the second or third day."

Then he recalled, "I did see one fractured pelvis with a ruptured ileum."

"Where did you see it?"

"On the orthopedic service."

"What day did you see it?"

"The surgical service was called in on the fourth day. He died on the fifth day."

I think we have a great responsibility. Where there are so many of our hospitals that at the present time are insisting that the patient with a fracture go to the orthopedic section, and when the majority (and I think that is true in most places)

of the non-penetrating abdominal injuries are a part of multiple injuries, I think we ought to make an effort for general surgeons to see those cases in which there is any question of a possibility of injury to the trunk, chest or abdomen. In a good part of the cases of fractured spine without paralysis and in all of the fractured pelvis cases, I think it would be much safer if all of these patients could go on a general surgical service and be looked out for by a general surgeon. I have known of some hospitals in which a fracture of the ribs automatically goes to the orthopedic section. It is just as simple to call an orthopedic man in to handle the fracture as a consultant on the general surgical service as it is to insist that every single fracture go to the orthopedic service, and you can usually depend on it that the general surgeon is better equipped to watch that case than the man on the orthopedic section who has to call in a consultant when he feels it is necessary.

In those hospitals in which fractures automatically go to the orthopedic section, I would like to plead for an arrangement whereby we consider sending only fractures of the extremities to the orthopedic section since the patient rarely is going to die in the early stages. Fractures of the trunk region, however, should not be sent to the orthopedic section because if the patient is dying from an abdominal injury, he may be saved by being under general surgical observation in the first few hours.

Everett P. Coleman (Canton, Ill.): It has been emphasized that on some occasions a penetrating injury to the abdomen, an injury just to the pancreas, is hard to recognize. That brings to mind an experience I had about a year ago which goes further than that.

A farmer's wife was alone one day and found a fox in the chickenyard. She hunted up her husband's revolver which she did not know how to use. She couldn't cock it so she turned it around toward herself and cocked it so that the gun went off. She was brought to the hospital shortly after the injury occurred. Upon examination the abdomen was found to be soft but there was the entrance of a bullet wound just above the umbilicus due to the passage of a revolver bullet of 32 caliber. There was some tenderness present but surprisingly little. The bullet could be felt under the skin just to the left of the spinous process of the eighth dorsal vertebra so it had apparently gone straight through the abdomen. With this direction in mind it was believed that it surely must have damaged some vital organs, perhaps several of them. On this account a laparotomy was done at once. When the abdomen was opened there was no blood and no fluid; but an opening where the bullet had passed was found between the stomach and the colon, the bullet apparently having passed beneath the stomach and above the colon. The track was then followed up and it was found that the bullet had passed just above the pancreas and had also missed the splenic vessels. From there it was found the opening led between the aorta and the vena cava. As you can imagine, this area was explored with the utmost caution and I felt certain I would almost surely run into a hemorrhage which might readily become uncontrollable. To my amazement, however, neither vessel appeared to have been damaged. The bullet had then struck the anterior surface of the spinal column, had penetrated it but had veered off slightly to the left and therefore had missed the spinal cord. This bullet had done absolutely no damage and I would like to record this woman as being the world's worst shot.

Chester C. Guy (Chicago, Ill.): I want to comment on Dr. Halter's paper, particularly with reference to traumatic pancreatitis. About twenty years ago there was a prominent man in Chicago involved in an automobile collision. He was driving; he suffered a broken arm and the steering wheel bruised his upper abdomen. He had mild symptoms which steadily increased but he did not become seriously ill until about ten days later. He eventually died of pancreatitis. At that time several very reputable pathologists and clinicians testified that there was no such thing as traumatic pancreatitis. Now I am sure we must all agree that there is.

In fact in our experience in Chicago I would say that the three most clear-cut etiologic factors in pancreatitis are biliary tract disease, chronic alcoholism and trauma.

In connection with injuries of the duodenum I saw an autopsy specimen showing two retroperitoneal ruptures of the duodenum that occurred in a young colored male who fell a distance of 10 feet and struck his right upper quadrant on a hard object. His early symptoms were not marked. He was observed for about twenty-four hours after which he suddenly became critically ill. He was explored through a totally inadequate incision and died twelve hours later. After seeing this autopsy I was struck by the peculiar greenish brown edematous appearance of the retroperitoneal tissues about the duodenum and the head of the pancreas. His death was due to a severe retroperitoneal phlegmonous type of infection.

Since that time I have had the opportunity of operating upon two patients, both of whom received non-penetrating upper abdominal injuries from falls and both suffered retroperitoneal lacerations of the duodenum. In these cases my attention was called to the duodenum by the appearance of this peculiar discolored, edematous area posterior to the duodenum and pancreas. In one patient we operated early, mobilized the duodenum and closed the wound. The patient made a very prompt and

satisfactory recovery as there were no other injuries.

In the other patient there were other injuries, including a ruptured liver and hemorrhage in the pancreas. After a rather long and stormy illness, he also recovered.

I would like to suggest that at operation upon a patient who has received an upper abdominal injury, open or closed, the surgeon inspect the retroperitoneal tissues in the region of the duodenum and head of the pancreas. A greenish brown edema may indicate a retroperitoneal perforation of the duodenum, easily overlooked if not suspected. Such perforations, if not closed surgically, will result fatally.

CHARLES G. JOHNSTON (Detroit, Mich.): I think Dr. Cameron has shown pretty definitely that the posterior space is not as important as has been assumed and, furthermore, the best way to drain an abscess is the easiest and most effective way.

We do it both ways. If there is a lot of pus posterior and that is the simplest way to get it, we drain it there. Here, again, as I mentioned in herniorrhaphy problems, there is fixation of notions about it. One group will argue for a anterior approach and the other will argue for posterior. I am surprised there hasn't been an argument here about whether to incise front or back. To me it doesn't make any difference so long as you drain the abscess.

Another reason for getting up is that I think somebody ought heartily to disagree with Dr. Patterson's paper and no one has. In the first place I would take issue that he does not use transverse or other unusual incisions. I would point out to him that, in my estimation, the transverse incision is the usual one; especially when a patient is already hurt, it is not good philosophy to turn him out on the half-shell like an oyster from the xiphoid to the pubis to take care of a problem that can be taken care of without such a traumatic and destructive type of incision.

Furthermore, in relation to aspiration had I been discussing this paper in 1931, at which time I reviewed a book in which aspiration was suggested, I would have objected very strenuously to it. Aspiration in some instances, very carefully done, will help a person out and save a great deal of time. If one is concerned about operating or not operating, there surely is no harm done; even if one were clumsy enough to do harm with a small needle, it could be repaired at the time of operation. So we use aspiration and find it is very helpful in certain cases.

The other objection I would raise (and here again some ten years ago I would have thought it was not unusual) is with regard to the matter of packing the liver. We do not pack the liver because, as a rule, we cause more damage than the injury causes. There are terrific problems involved in taking the sponge out of the liver with all the necrosis that is present. If the liver is so badly damaged, or a portion of it, it should come out. Otherwise, it should be sutured.

A lot of people worry about the liver cutting through but this can be handled perfectly well by preceding the suture with a line of sutures along the split edge of the liver which will support your suture material. One does not have to worry about the suture cutting through because the suture which has been placed along the split edge of the liver will support it.

I think mention ought to be made that one of the most important and most difficult problems in relation to intra-abdominal injuries, especially stab wounds, is that there are blood vessels. Many times large blood vessels—the vena cava, aorta and mesentery vessels, chiefly the mesentery ones—can become involved and can cause a great deal more difficulty in handling, especially if there is a great deal of trauma around them.

I am quite surprised to find that in New York City the training of the residents stops at night. In Detroit we do not have that difficulty because in seriously injured individuals there is a staff man who supports and trains the resident. I take a Saturday night at the hospital myself and sleep in, and the rest of my staff do likewise. They are there not only for stab wounds and other types of trauma that come in but also for fractures. I think it is important that in busy services we do not stop teaching residents at night.

In some institutions they do expect the resident to carry the load at night. The staff man comes in and leisurely operates in the daytime and in such instances—and I think this should be avoided—insist that the resident help with the retraction and stand in the background; but at nighttime when the hard problems such as we have been talking about come in, and the patient cannot wait until morning, the resident goes ahead and does it himself. That, I insist, is very, very poor training. The young man, especially at night, should have the help of the staff man. If you want to leave the gastric resection to him the next morning that is fine, but I think we should not lose our interest at five o'clock at night because that is when most of this type of trouble occurs in our town.

JOSEPH E. HAMILTON (Louisville, Ky.): I would like to make a few comments on the excellent paper of Drs. Mathewson and Halter and to add three cases of traumatic pancreatitis. The first of these was a twenty-eight year old colored male. In a fight he had received severe kicks and punches to his head and abdomen. His abdomen presented 4 plus tenderness, spasm and rebound tenderness. He was explored with a preoperative diagnosis of possible rupture of liver or hollow viscus. Much dark

bloody free fluid and a greatly swollen, tense and hemorrhagic pancreas were found. With the pancreas so generally and seriously damaged, any search for possible suturable ducts was out of the question, as I believe it would be in most such cases. Several Penrose drains were placed to the pancreas and the wound closed. After a stormy postoperative course, including a bout of small bowel obstruction, the patient is back to work and in excellent health. Even in non-traumatic acute hemorrhagic pancreatitis that is not doing well on conservatism, adequate surgical drainage appears to be justifying itself in our hands. It would seem, furthermore, that the great amount of highly active juice as well as bits of digested pancreas that drain from some of these patients are better outside than inside the belly.

The other two cases of traumatic pancreatitis followed gastric resections in which difficult dissection was necessary to free sclerosed penetrating duodenal ulcers from the region of pancreatic head. Both patients had much more than the expected postoperative abdominal pain and tenderness, and both had abdominal distention. Their temperature and pulse rate were abnormally high. The blood amylase tests in the fatal case were normal, in the surviving case 650 to 700 Somogyi units.

One of the patients soon improved and went on to recovery without further trouble. The second passed into profound shock and died. Autopsy revealed acute hemorrhagic necrosis localized to the head of the gland. There was a common channel between the terminal portions of the common and pancreatic ducts but no evidence of injury to ducts or pancreas or of biliary disease. The etiology of these and similar cases is obscure. Possibly spasm of or, in occasional cases, mechanical occlusion of an existing common channel may allow bile to flow into the pancreas. This complication should be kept in mind in dealing with patients doing poorly and having an undue amount of pain after gastrectomy. A blood amylase determination will help confirm the diagnosis.

R. Arnold Griswold (Louisville, Ky.): Before I ask the essayists to close I should like to depart from protocol long enough to discuss Dr. Kennedy's discussion. Our problems in the training of surgeons and also of those who do surgery are not limited to traumatic matters. I know of cases in which obstetrically trained gynecologists opened abdomens for what they thought to be gynecologic problems, found cancer of the sigmoid and closed the patients. The patients were reopened by a general surgeon a few days later.

A third such instance was reported in The Archives of Surgery from a teaching hospital and, as far as I could gather from reading the report, without any sense of shame.

John H. Powers (closing): I have no quarrel whatsoever with the surgeon who wishes to do a colostomy on the patient with a perforation of the rectum and pouch of Douglas, provided that the welfare of the patient and the mental equilibrium of the surgeon can thus best be served. My reasons for not doing so in civilian surgery, with all its modern adjuncts for safety, were stated and I believe are tenable.

I likewise have very little quarrel with the surgeon who wishes to leave the perineal wound open. All the four patients in this exceedingly small series received antitoxin against the gas-forming organisms. In none of them did a gas bacillus infection develop. Whether or not the antitoxin had anything to do with it, I do not know. My reasons for preferring to close the perineal wound were likewise stated as they apply in a civilian practice. I think the situation may be different in military surgery—it is different. We are talking about civilian surgery.

I thoroughly agree with Dr. McKim that proctoscopy under anesthesia is a dangerous procedure. It may be hazardous without anesthesia; certainly in the hands of an inept and unskilled individual, the proctoscope is a dangerous instrument. Most examinations can be done without anesthesia. There may be an occasional patient with a tight sphincter or one with a very sensitive sphincter for whom some type of anesthesia seems desirable.

I believe it is imperative for members of the house staff to receive as much training in the use of the proctoscope as they receive in the use of the cystoscope, esophagoscope, bronchoscope or gastroscope in order to be safe.

There are certain other things which, in my opinion, contribute to the safety of the proctoscope, namely, a well lubricated instrument, the patient in proper position, inflation of the bowel as the tip of the instrument is advanced. These details all will contribute to the safety of a proctoscopic examination.

I likewise agree with Dr. McKim that many of these wounds—and many of them do not get into the literature—are due to the rough usage of hard rubber nozzles for the administration of enemas by nurses, orderlies and the patients themselves. Patients are much more apt to admit such an accident than is the doctor or the nurse who produced it. Patients should be trained, nurses should be trained, nurses' aides should be trained and nurses' helpers should be trained that it is necessary to introduce a soft rubber tube only 4 inches in order to give an adequate enema. Farther than that is hazardous and unnecessary.

Finally, I wish to emphasize again that two of the patients whom I discussed were operated upon before the days of penicillin when the local use of sulfonamides was thought to be desirable. To the best of my knowledge no one uses the sulfonamides locally any longer.

BERT L. HALTER (closing): I have little to add but to thank the discussants. I have no quarrel with those who want to drain the pancreas. If you do operate upon the patient and find a marked contusion and a laceration so extensive that it cannot be sutured, it is perfectly permissible to drain the pancreas. We do drain the lesser sac, as I stated, if we find any extensive accumulation of fluid, and I believe those patients may or may not be improved by this drainage.

In the acute hemorrhagic pancreatitis in which the capsule seems to be dissolved, we have had disastrous results with or without drainage.

RUSSELL H. PATTERSON (closing): Right or wrong I very frequently proctoscope a patient when he is under an anesthetic. I like one more look before doing a hemorrhoidectomy in an older person or when removing a rectal polyp. We have gotton into no trouble yet.

Another thing that Dr. Powers mentioned was passing a tube beyond the suture line after suturing the lower bowel. They are doing that around New York City now some, but I do not like a tube lying on the suture line. I understood him to say he did that. You can have a general rule that the closer a wound of the colon is to the cecum, the less often you have to do a colostomy; but as far as I am concerned, for an intraperitoneal wound produced through the rectum, I would rather have a colostomy. With rectal wounds below the perineum, if you can get a good drainage below, of course I do not think one is necessary.

The question in pancreatitis about draining and not draining, and who gets well and who doesn't, I think, depends on whether or not the body of the pancreas or one of the main pancreatic ducts is injured. If there is contusion, you get a certain amount of fat necrosis and the patient may get well; but if you have a real laceration of a pancreatic duct, especially the main one, that patient is going to die if the duct wound is not closed. Of course, those cases that have been diagnosed even with the abdomen open are extraordinarily rare. I happen to know of two. One was sutured with cotton and recovered; the other had a tube placed in the duct wound and is still draining.

Dr. Penberthy's remarks on the duodenum were very pertinent. The mortality of those cases in our hands has been frightful, something like 75 per cent.

I appreciate Dr. Kennedy's arguments about non-penetrating multiple injuries, and I would say in regard to Dr. Coleman's report about this bullet winding all around through the abdomen and hitting nothing, that that bullet was directed by God.

Dr. Johnson came right back at me with both fists and that I appreciate. Everybody knows that he is an authority on abdominal injuries and don't think I didn't read his section of Christopher's Surgery before I got up here. I do not mean to make an autopsy incision when I operate upon an injured viscus. I try to use my judgment and go somewhere in the neighborhood of where I am going to work, and I think the quickest way is to do it at midline or one side or the other.

As regards the liver and suturing the liver, we have used fat and we have used muscle, we have packed them and we haven't packed them, and we have closed them up without drainage and with drainage. We have had two cases that we sutured perfectly beautifully only to have the liver bleed further under the sutured capsule. Three weeks later in one case, and about forty days in another, there was a sudden explosion and the patient went into shock. One patient died and the other came back into the hospital. It was essentially the same thing as a delayed rupture of the spleen in which the capsule may seal off or it isn't broken, but eventually that clot will liquefy and get you into trouble.

So, on those large liver injuries if you can use mattress sutures and take out a part of the liver, all well and good, but we still are packing them. We leave the packing in there a very long time, until it practically pushes its way out—three, four, five, six weeks—and they all get infected.

Dr. Johnston (and I put down here an exclamation point) says he stays at his hospital one night a week! In New York, we are lazy; we don't do that. At night our emergency wards are covered by internes and assistant residents. The emergency ward is regarded as a dirty job and the resident staff and the visiting staff would all rather be upstairs doing esophagectomies and patent ductus arterioses and other such things.

Emergency care of patients in the evening and at night in New York are handled in general as follows: The ambulance is called (there is a delay there), the patient is brought to the emergency ward and one of these humble fellows who is on duty goes down and sees the patient, and then he calls the resident on duty, and then that resident may or may not call a junior visiting, and the junior visiting would be coming pretty fast if he got there within an hour. Am I exaggerating, Dr. Kennedy?

DR. KENNEDY: Not a bit.

DR. PATTERSON: That is the way the situation is handled in New York and from the time a man is injured until he gets good care in the operating room is a matter of hours in New York City, in the nighttime. In the daytime the older surgeons and specialists get around to the hospital, the full staff is on duty and the injured patients get more immediate and better care.

Symposium on Vascular Problems

RESTORATION OF BLOOD VOLUME IN SERIOUSLY INJURED PATIENTS*

WITH SPECIAL REFERENCE TO INTRA-ARTERIAL TRANSFUSION

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OUR assignment is to present to you a practical discussion on the effects of depletion of blood volume in severe trauma and on methods for its restoration. Time will not permit our entering into the still controversial field of the pathogenesis of shock, but we will, instead, outline our experience with intra-arterial transfusion in resuscitation.

EFFECTS OF BLOOD LOSS IN THE SEVERELY INJURED

Since World War I laboratory investigators[1,8,2] have been producing generalized capillary permeability to plasma with associated oligemic shock and hemoconcentration in experimental animals by use of histamine-like substances. Nevertheless, clinical observers[3-7] of severely injured humans are consistently finding that traumatic shock is due to hemorrhage with hemodilution and that its gravity is in direct proportion to the amount of blood lost. In support of this we need only consider the hindquarter amputations, abdominal viscerectomies, terrific thoracic operations and many other procedures formerly spoken of as shocking but that are now well tolerated by the patient whose blood is replaced as it is lost and whose blood volume is thus constantly maintained or overcorrected. Victims of accidental trauma receiving similar and timely treatment should make a similar satisfactory response.

Although in most instances traumatic shock is hemorrhagic shock, associated with hemodilution, exception must be made for severe burns, late cases of peritoneal soiling from lower bowel perforations and claustridial myositis in which there is a selective plasma loss at the site of injury and relatively little hemorrhage. Here hemoconcentration rather than hemodilution may be expected. In either case there is a reduction in effective blood volume, reduced venous return to the heart, reduced cardiac output and hypotension leading to stagnant hypoxia in the capillary beds. This, if uncorrected will, in spite of maximal vasoconstriction, lead to death or irreversibility.

Stewart[8] has found that the average healthy adult can lose one-third of his blood volume rapidly without dying or upward of 1,500 to 2,000 cc. of blood. However, McMichael[5] has shown that even relatively small acute losses of blood must be compensated for by a considerable increase in peripheral vasoconstriction. Thus in a normal volunteer, during a hemorrhage of only 900 cc. and during which his blood pressure remained normal, the pressure in the right auricle fell 6 cm. of water and there was a parallel reduction of cardiac output from 4.85 to 3.2 L. per minute.

The anatomic region of injury will have some effect on the nature of the resulting shock. Brain injuries show surprisingly little shock in proportion to their gravity and danger to life because there is very little blood lost. Cord transections result in a neurogenic type of collapse from generalized vasodilatation. Extremity injuries are usually associated with

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considerable bleeding into the damaged part as well as externally and thus show greater hemodilution than thoracic and abdominal trauma. McMichael[5] likened the adult thigh to a conical container. If its diameter is increased by only 2 cm., its capacity will be increased by 1,400 cc. In penetrating abdominal wounds Griswold,[9] and Hamilton and Duncan[10] found shock directly proportional to hemorrhage and, furthermore, massive hemorrhage was the most important single factor in mortality. In chest injuries, in addition to the shock of blood loss there is also the shocking disturbance of intrathoracic physiology such as cardiac tamponade, sucking wounds and tension pneumothorax.

In patients surviving the initial circulatory collapse, hemodilution with anemia and mild hypoproteinemia uniformly persists for a week or more in spite of repeated whole blood transfusions.[3,4] If plasma has been the chief transfusion fluid, the anemia will be greatly exaggerated.[6] This situation promotes tissue edema, poor wound and fracture repair,[11,12] and swelling and delayed healing around gastrointestinal suture lines.[13] Prolonged hypotension and the associated stagnant hypoxia within the capillary beds lead to two other delayed sequelae, namely, the dreaded lower nephron syndrome and increased vulnerability to infection of contaminated wounds. The renal complication is thought to be occasioned by degeneration of tubular epithelium from the anoxia and perhaps to precipitation of hematin within the tubules.[14] As to the infection in the contaminated wounds, we well might expect bacteria to gain a foothold in tissues devitalized by anoxemia and accumulated metabolites.

RESTORATION OF BLOOD VOLUME IN THE TRAUMATIZED PATIENT

As thorough and rapid as possible examination of the patient is obligatory to disclose all the injuries and their potential of hemorrhage and shock. Thus, were a cardiac tamponade or sucking chest wound overlooked, a barrel of blood given by vein or artery would be of little avail. With teamwork several diagnostic and therapeutic procedures should proceed simultaneously and rapidly.

We have observed as have Keckwick,[7] Stewart[15] and others that the blood pressure is probably the most valuable single indication of the severity of injury. Stewart found a rough correlation between blood pressure and blood volume. Thus the blood volume of five patients admitted with blood pressure of zero averaged 58.7 per cent; the blood volume of twenty patients with blood pressure less than 100 averaged 77.5 per cent and the blood volume of twenty-one patients with pressure of 100 or better averaged 81.6 per cent. However, it is well known[4,7] that vigorous vasoconstriction and a lag in hemodilution may temporarily mask grave injury and impending collapse. The oligemia and hypotension must be corrected quickly or it will progress inevitably to a fatal conclusion. Plasma may be preferable for the occasional case showing hemoconcentration, but in the great majority whole blood should be supplied because of its protein content and oxygen-carrying capacity. Snyder[6] recommends for a patient with zero blood pressure 1 or 2 pints of low titer group "O" blood given in five to fifteen minutes. The first 2 pints, in real emergency, need not be cross-matched but all blood after the first 1,000 cc. should be. This same author also reported that the surgeons in the North African and Italian campaigns agreed that whole blood was not only superior to plasma in the treatment of the immediate shock but also that the soldiers receiving whole blood convalesced more smoothly and did not have the anemia shown by those receiving largely plasma. It is a fair estimate that each pint of blood will raise the recipient's red cell count about 300,000 per cu. mm. and the hematocrit about 2.5 per cent.[4] Keckwick[7] found that each 540 cc. bottle of blood raised the blood pressure 10 to 20 mm. mercury in battle casualties and that in order to obtain a systolic blood pressure of 100 or over it was necessary to transfuse not less than 50 per cent of the calculated blood loss.

What is a safe level at which to desist from our immediate restorative measures? Beecher[16,17] emphasizes that complete restoration to normal of the circulation and vital organs is not possible for many days nor is it necessary or advisable for immediate safety or in preparation for necessary surgery. If the blood pressure swings up to 85 systolic, the pulse rate tends downward and the skin is warm and of good color, the patient is ready for immediate surgery; or if this cannot be undertaken at once, the patient may be maintained safely with these signs for several

hours until the surgeons can get to him. Beecher further stated that, under this plan of management, of the worst wounded of 2,853 battle casualties at the Anzio beachhead, none died during surgery and the over-all mortality of 1,623 casualties who did not die on the battlefield was 1.48 per cent. We agree with Beecher's estimate of a safe preoperative level of blood pressure, especially if this be combined with an upward tendency and with other favorable signs. However, we believe from our own experience that it is better to continue resuscitative measures further than this when blood is available, if for no other reason than that by so doing we will lessen the anemia and hypoproteinemia of early convalescence. The prompt control of further hemorrhage in the traumatized patient takes precedence even over blood replacement for, just as true as the saying, "A penny saved is a penny made," is the fact that blood not lost need not be returned.

Autotransfusion. A word should be said for this readily available source of blood. Griswold and Ortner[18] in 1943 reported 100 consecutive autotransfusions in a variety of emergencies with excellent results and only one proven fatality attributable to the method. In this case there was a known error in filtration allowing multiple pulmonary emboli. Fresh uncontaminated blood from the abdominal or pleural cavity should be returned to the patient and not wasted. It should be stressed that even when there have been associated injuries of the liver, stomach or bowel, autotransfusion has been repeatedly used by us as a life-saving measure and without known sequelae when enough donor blood was not available. Hamilton and Duncan[10] cite four striking examples of this among their cases of perforating abdominal injuries. (These were also included in Griswold's and Ortner's series.)

	Autotransfused
Lacerations of liver	2,000 cc.
Lacerations of stomach and liver	800 cc.
Ileum perforated four times	1,500 cc.
Ileum perforated twelve times	1,200 cc.

The blood, sucked from the wound, citrated and filtered through ten thicknesses of gauze into a sterile Kelly bottle, is ready to return to the patient.

Necessary operation upon the critically injured should not be divorced in our minds from the other resuscitative measures, since its prime purpose is to control hemorrhage and to correct traumatic distortions and defects that help to perpetuate shock. Blood, of course, should be started at once while the operating room is being prepared. If in the forty-five minutes to an hour required for this the patient's condition improves, well and good since it is preferable, as induction of anesthesia begins, that the blood pressure be at least 80 systolic and preferably rising. If there is little or no improvement during this interval, it must be assumed that there is continued active bleeding or other shock-producing factors requiring surgery. Operation should therefore be started although at the same time shock therapy is continued. In short, in spite of the practice in some quarters of delaying surgery until the patient is "out of shock" or "stabilized," it scarcely seems logical to hope that blood dribbling in through a needle will by itself restore a patient who may be bleeding briskly from some torn internal vessel. Also, as Griswold[9] has pointed out, "Gentle expeditious surgery with the patient under suitable anesthesia will not appreciably aggravate shock particularly when adequate replacement therapy is going on." The surgeon, when faced with massive bleeding, should avail himself of good suction to clear the field of excess blood, and incidentally, when feasible, to collect it in a citrate bottle for reinfusion. Also he should not forget to put his finger either upon the bleeding point or to apply proximal compression on the bleeding vessel. Thus liver hemorrhage can be checked by simply compressing the hepatic stalk at the foramen of Winslow.

ARTERIAL TRANSFUSION

The intra-arterial route for transfusion, rediscovered and suggested as a practical procedure by Seeley[28] in 1939, has been found successful in resuscitating patients in shock many times when the intravenous method was unavailing and it should be reserved for such situations. It would be wise to have it in readiness when starting a hazardous operation when there is the expectation of large blood loss. Since the recipient artery may have to be sacrificed in the procedure, it should not be used in terminal stages of hopeless disease.

Physiology. The effect is immediately to

raise the arterial pressure and thus directly to perfuse the coronary circulation, the liver, kidneys and vital centers. Page[19] and Jones et al.[20] found that in dogs, rendered apneic by profound hemorrhagic shock, the sudden injection of blood within the arterial system

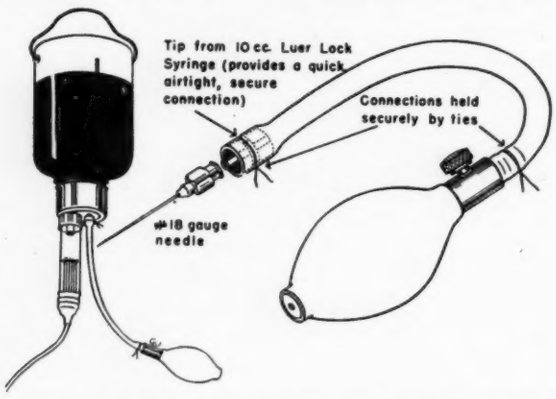
Tip from 10 cc. Luer Lock Syringe (provides a quick airtight, secure connection)
Connections held securely by ties
#18 gauge needle

FIG. 1. A simple, commercially available dispensable recipient set with bulb and tube for pressure added.

caused a gasp followed by resumption of respiration. When blood is injected into an artery distal to the heart, it will not produce pulmonary edema, whereas when it is injected into a vein in advanced shock, it is simply piled up by the right heart in the pulmonary circuit behind the flagging left ventricle. This results in pulmonary engorgement and edema. Kohlstaedt and Page[21] bled dogs to severe shock by standard methods, then reinfused 50 per cent of the blood withdrawn. Thirty per cent of dogs receiving their blood by vein recovered, whereas 75 per cent receiving blood by artery recovered. These authors also found that much less blood was required to abolish shock when given by artery than when given by vein. These findings have been corroborated clinically by numerous investigators.[22–26]

Several dramatic case reports of intra-arterial transfusion stand out in the literature. Gold, Rosenthal and Schotz[26] reported a negro patient in profound collapse from intestinal obstruction. He had already received 1,000 cc. of intravenous blood and was beginning to develop pulmonary edema when he was given rapidly 1,000 cc. blood in an artery. He was restored from shock and recovered. A patient of Ciliberti and Dickler,[24] just after a pulmonary resection, suffered a massive hemorrhage resulting from a ligature cutting through the pulmonary artery. He had ceased to breathe and his heart was at a standstill. Twelve hundred cubic centimeters of blood were given intravenously under pressure without benefit in a period of fifteen to twenty minutes. Then 1,200 cc. of blood were given by the intra-arterial route with almost immediate recovery from shock. Negovski[27] transfused by artery ten Russian soldiers in a state of clinical death from blood loss. That is, their respirations and heart beats had ceased for upward of five minutes. Five of the ten completely recovered. (Fig. 1.)

Technical Details. We have heard surgeons say, "I wish we were set up for this method," as though they believed a complicated apparatus or technic were required. Actually the whole procedure is simplicity itself. The apparatus we have used is shown in Figure 1 and consists of a high pressure disposable recipient transfusion set, available on the market, with an attached sphygmomanometer bulb and tube to supply pressure. If the recipient is on the operating table, a radial artery is exposed at the wrist and under direct vision a Lindemen stylett needle is inserted but not tied in. At completion of the transfusion the artery can usually be salvaged by a simple compression dressing over a stitch or two to the skin. When the thighs are available, we have nearly always been successful in blind insertion of a No. 16 or No. 18 needle into the femoral artery. With the needle in one or the other artery and pointed toward the heart, the surgeon or anesthetist pumps blood in with the hand bulb. The rate of delivery may be as fast as 500 cc. in five to ten minutes and is dictated somewhat by the urgency of the case. In one patient with terminal bowel perforation and gas gangrene who arrived with unobtainable blood pressure, 2 pints of blood and 2 pints of plasma were infused in thirty or forty minutes. Although death inevitably supervened, autopsy revealed no significant degree of pulmonary congestion. As the blood is running in, the patient is constantly under medical observation. This includes repeated checking of general condition, blood pressure, appearance of veins, auscultation of heart and pulmonary bases when these are accessible and close watch to prevent sudden emptying of blood bottle and air embolus. Except in hopeless cases in which the procedure is used as a forlorn last measure, the rule is for a surprisingly quick restoration of substantial blood pressure, usually after

200 to 300 cc. of blood have run in in a matter of three or four minutes. This is especially dramatic when as is usually the case, intravenous infusion has been unavailing. (Table 1.)

Arterial transfusion has been used at the Veterans and Louisville General Hospital

TABLE 1

RESULTS OF INTRA-ARTERIAL TRANSFUSIONS

Patients transfused	31
Episodes of shock treated	36
Definite benefit	17
No benefit	19
Spectacular benefit following failure of intravenous transfusion and considered life saving	9
Total arterial transfusions (several episodes of shock required repetition of arterial transfusion)	46

forty-six times in treating thirty-six separate episodes of shock and Table 1 summarizes the pertinent data. It will be noted that of the thirty-six emergencies treated, nine were successful after intravenous transfusion had failed and were considered life saving. In seventeen instances the procedure was definitely helpful and in nineteen instances it was of no appreciable benefit. The failures include cases of terminal sepsis or malignancy in which subsequent events proved that any measures would have been ineffectual to half the inevitable conclusion. In no case, however, did we believe that the intra-arterial transfusion contributed to death and the only serious complication encountered was embolism of the right femoral artery (recipient artery). A successful embolectomy was carried out and the patient survived.

The following three case summaries illustrate spectacular responses to intra-arterial transfusion.

CASE REPORTS

E. Z., a twenty-eight year old colored male, was admitted in deep shock from a laceration of the jugular vein. The vessel was ligated immediately in the operating room. Intravenous transfusion of 200 cc. blood had been given when the patient appeared to be moribund with loss of consciousness, gasping respirations and systolic blood pressure of zero. Intra-arterial transfusion of 500 cc. blood was given through the radial artery. The patient's response was dramatic with immediate rise of blood pressure to 100 systolic and return of consciousness. Recovery was uneventful.

J. C. was a forty-three year old colored male with a stab wound of the left auricle, who exhibited profound shock following repair of the auricular wound and in spite of 2,000 cc. blood given intravenously. An intra-arterial transfusion of 1,000 cc. blood was given through the radial artery with restoration of blood pressure to 110/70. Recovery was uneventful.

T. L. B. was a twenty-four year old white male who underwent pulmonary resection for far advanced tuberculosis of the right upper lobe. The operative procedure was difficult with constant oozing of blood in spite of all attempts at hemostasis. After four and a half hours of surgery, in spite of 6 pints of blood intravenously, the patient went into profound shock. Arterial transfusion of 1,500 cc. blood through radial artery was given and the blood pressure returned to 85/60. At this time an intravenous infusion of 500 cc. blood was given but the blood pressure fell rapidly to 0/0. Another intra-arterial transfusion of 1,000 cc. blood was given through the femoral artery with restoration of the blood pressure to 105/70. This patient went on to eventual recovery.

SUMMARY

The problem of blood volume restoration in the severely injured is presented from the following standpoints: (1) effects of blood loss in the severely injured, (2) restoration of blood volume in the severely injured and (3) our practical experiences with intra-arterial transfusion.

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DISCUSSION

James C. Drye (Louisville, Ky.): It is interesting to speculate on irreversible shock, the possible etiologic role of central failure, of a vasodepressor material being formed in the liver and the possibility of using an agent that can neutralize this vasodepressor material. Also, the problem of lower nephron nephrosis is important and requires much more study as the management of this, at present, highly fatal complication leaves much to be desired.

However, it must be remembered that patients can and do die of shock before there has been time for irreversible shock to develop, or lower nephron nephrosis to occur, if no treatment has been possible or if the treatment has been inadequate. I suspect that most of the deaths due to shock occur in this manner.

Further, it should be stressed that both irreversible shock and lower nephron nephrosis are a product of time, as well as the degree of shock. If we can attain an adequate blood flow soon enough, the severest degree of oligemic shock can be corrected and both irreversible shock and lower nephron nephrosis avoided.

In our clinical experience irreversible shock and lower nephron nephrosis have occurred in oligemic shock only if this shock has existed for a considerable time. Also, it has been found necessary to keep the arterial pressure very low for about an hour before irreversible shock can be produced experimentally.

Thus, it is evident that adequate blood flow must be attained before time runs out. Giving blood by simple intravenous drip thus increasing the blood volume and the cardiac return is sufficient to attain a satisfactory blood flow in the majority of cases. In the more critical cases in which the heart and the vital centers have begun to fail because of severe acute anoxia it is necessary to inject blood under pressure into the arteries which directly increases the head of pressure and forces blood into the coronary arteries and the arteries of the vital centers as well as increasing the blood volume and the cardiac return.

Now a word about the evaluation of the degree of shock and of the progress of the shocked patient.

The evaluation of the degree of shock depends upon the type of injury and consideration of several clinical signs. No one clinical sign is completely reliable in an individual patient. John Stewart observed that in a large group of patients the blood pressure was a rough index to the blood volume, but that in an individual patient there may be little or no correlation. We too have observed patients, usually the young and hearty, who had a normal blood pressure but who were certainly in shock. The type of pulse, skin color and temperature, the appearance of the veins, and the patient's mental state should all be considered.

In certain type injuries shock can be anticipated with certainty regardless of physical signs. Severe compound fractures of the femur and traumatic amputations are good examples of such injuries. Some hearty individuals with such injuries may show surprisingly little clinical evidence of shock, particularly if seen early. However, vigorous replacement therapy should be instituted in spite of the lack of physical signs in such cases.

In evaluating the progress of the patient in oligemic shock undergoing replacement therapy, we depend entirely on the clinical response. Blood

counts, hematocrits and blood volumes are of no value. The trend of the physical signs mentioned before are most significant. While one isolated blood pressure reading may be misleading, a rising or falling blood pressure means a great deal. Changes in the skin temperature and color are of significance. To me the appearance of the veins of the hands and arms have meant a great deal. As long as the veins are flat and empty, more blood is needed and may be given with impunity. The filling of the veins is usually accompanied with a rise in blood pressure and return of skin warmth and good skin color.

If the filling of the veins is accompanied with a continued low blood pressure, and particularly if the skin takes on a dusky red appearance noticed best about the head and arms, the outlook is bad. It means that in spite of restoration of blood volume and an adequate venous return the cardiac output is low and the patient is probably in irreversible shock.

STANDARDIZING THE TREATMENT OF TRAUMATIC INTRACRANIAL EXTRAVASATION

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A SURVEY of the surgical literature dealing with the intracranial extravasation of blood following cranial injury emphasized the following three points: (1) The early eighteenth century readiness to open the skull by means of trepanation was checked later in the nineteenth century by unfavorable experiences involving usually the death of the patient. (2) Confusion has been present throughout the past in identifying both the presence and the site of an intracranial extravasation. (3) A multiplicity of surgical methods have been and still are employed in treating the unlocalized intracranial extravasation of blood.

It is our purpose to arrange the surgical background into some order by summarizing historical experiences. Before this background, we would set in relief a concept of standardized management which new technics and materials now permit.

Concerning Eighteenth and Nineteenth Century Management. It was not until the eighteenth century that physiologic principles, both right and wrong, became matters of concern to the surgeon at a period of renewed interest in cranial trauma. It was held that a "concussion" or "commotion" of the brain followed cranial trauma. This state was followed by a period of "compression." Such "compression" was comparable to "inflammation" or a state of the cerebral tissue comparable to that of other soft tissue in the body which had undergone injury. The concept was also held that when blood was extravasated, even in small quantities, into the cranial cavity, such collections suppurated and added to the state of inflammation already present. As Heister stated in 1739, "if the quantity of extravasated blood be ever so small, it will certainly corrupt and affect the brain and meninges itself." He strongly recommended that the trephine be used, a concept held also by Pott, who advised operation, "with the view to prevent the inflammation and suppuration of the dura mater." It was thus common practice for surgeons in this early period "to make numerous perforations along the whole tract of a fracture of the cranium."

Opposed to such eighteenth century practices, however, were a conservative group of authorities, including Desault of France, Richter of Germany, and Dease and O'Halloran of Ireland. They opposed the views and practices of the older surgical group, often identified as the school of Pott, and restricted the use of the trephine operation. Abernethy, who evaluated these contrary opinions in 1811, supported the conservative view, stating that the injury inflicted in the operation of trephining would probably aggravate "the inflammatory symptoms which are to be expected to succeed to all violent blows of the head."

Abernethy, however, clearly described an extradural collection produced by disruption of the middle meningeal vessels; he reviewed three cases all of whom died, and recommended "that the nature of such cases be accurately distinguished." Abernethy had also noted the occurrence of blood beneath the dura, but the difficulty of removal forced the conclusion "that extravasation between the dura mater and the cranium is almost the only case that admits being remedied by the use of the trephine."

Based upon the information afforded by postmortem examination, it was recognized that extravasation of blood occurred at several sites within the cranial cavity. By the nineteenth century these sites were reported at "five different points: (1) between the dura mater and skull; (2) in the arachnoid sac, on the surface of the brain; (3) beneath the arachnoid membrane in the furrows of the hemispheres; (4) in the substance of the brain; and (5) in the lateral ventricle." There was agreement in the middle of the nineteenth century, with the views of Abernethy, that extravasations of the first type, namely, that between the dura mater and skull were the

most frequent and that only this extravasation warranted surgical interference. The results, however, were exceedingly poor. Prescott Hewitt noted that the extradural extravasation was common; that it sometimes occurred from the lateral sinus, as well as the middle meningeal artery; that frequently associated brain damage occurred. He concluded, "this easily explains the difficulties as to diagnosis and the reason why the trephine is so seldom applied nowadays for extravasated blood; why also, when resorted to, the operation so seldom succeeds." All teaching in the nineteenth century opposed the views of Heister who had urged, "it will be necessary to trepan first on the right side and then on the left side of the head, and afterwards upon the forehead, and lastly upon the occiput and so all around until you meet with the seat of disorder." Similarly, the recommendations of Benjamin Bell were contested. He had stated, "we must form the first perforation in the most inferior part of the cranium, in which it can with any propriety be made, and proceed to perforate every accessible part of the skull until the cause of compression is discovered."

Macleod, along with Stromeyer, Nelaton, Guthrie, Erichson and Gross fostered a conservatism during the nineteenth century. Gross stated, "when the blood is accessible, it is obvious enough that it should be evacuated, but how is this to be known, how can it be determined whether it is situated immediately beneath the cranial bones, upon the hemispheres of the brain, at the base of the skull, in the cerebral substance, or within the ventricles." He stated that occasionally when suggestive signs and symptoms are present, "the surgeon, especially if he is fond of operating, may feel inclined to perforate the bone. But is he right in doing so? Possibly he may find the object of his search, but he is groping in the dark and there is quite as much likelihood that he may fail as that he may succeed. A surgeon makes occasionally a fortunate hit, but how often has the operation failed? Where one surgeon has succeeded, twenty have been disappointed."

Confusion in Diagnosis Has Always Existed. The typical epidural or subdural hemorrhage may be accurately diagnosed. These are outnumbered by the atypical "suspects." In this latter group, based upon clinical signs and symptomatology, the diagnosis of the subdural hematoma in particular, whether acute, subacute or chronic has been recognized as being most difficult. Similarly, an intracerebral collection may be overlooked. This has been not only the experience of the past but also of the present. In the past, the inability to localize a collection led to a restraint in the use of the trephine. Then recently the trephine came into use again as a means for diagnosis, the cavity of the skull being searched by means of multiple small openings, the method used by Heister 200 years ago. Coleman in 1935 pointed out, "Singular bilateral trephine openings in the upper temporal region offered perhaps the only method of recognizing many of the acute clots in time to save the patient." Bucy in 1942 reported, "it is obvious from the study of these cases that subdural hematomas present most variable clinical pictures of cerebral disturbances." He suggested that diagnosis be made by trephine openings. In 1943 Browder reported his experiences with a group of 289 cases of subdural hematomas and was led to the conclusion that "an accurate diagnosis seldom is possible from the clinical features alone. In by far the majority of instances, there were associated intrinsic brain lesions productive of abnormal physical signs which served to confuse the diagnostic issue." In 1949 Echlin reported a group of patients with serious head injury among whom seventy were operated upon and subdural hematomas evacuated. In addition, there were thirty-five patients who were suspected of having a subdural collection of blood who were also explored but no collection was found. This illustrates not only the common plan of using the trephine as an aid in diagnosis, but also the error which the method may involve (33 per cent in Echlin's cases). A common practice has been the employment of ventriculography at the time of "burr opening exploration" for a collection. If the collection is not found through bilateral openings, air may then be injected into the ventricular system and roentgen studies made. Multiple burr openings are then avoided. In the acutely ill patient, however, the use of air added to the existent trauma has disadvantages.

Various Surgical Methods Have Been Used in Treatment. A multiplicity of surgical methods have been employed in treating the unlocalized extravasation, particularly the subdural hematoma.

The treatment of the epidural hematoma

logically evolved from the early successful experiences which had occurred on a trial and error basis. The old method of "setting a large crown upon the trephine," making an opening in the skull was subsequently found at the turn of the nineteenth century to expose and permit the evacuation of an underlying collection on the surface of the dura. The distribution of the middle meningeal artery located the site for the bony opening. Later asepsis insured wound-healing. The availability of the temporal muscle and fascia for closure led to the intermuscular subtemporal decompression operation of Cushing. This has been used for many years and has standardized the treatment for the epidural collection when the diagnosis and localization of the collection can be accurately made.

The evolution of the treatment for the subdural hematoma, however, has not resulted in a similarly uniform operation. The occasional subdural collection which was encountered in the early part of the nineteenth century was treated by means of a "decompression" opening. The opening was usually in the temporal bone made for the purpose of evacuating an epidural hematoma. In the absence of the epidural collection, a bluish, bulging dura served to identify an underlying subdural collection which was then evacuated. It was early noted that the evacuation was not adequate as reported by Abernethy. Sachs and Elsberg in 1916 confirmed Abernethy's observation and employed a secondary bone flap. In 1925 Putnam and Cushing considered the problem of treatment in the chronic type of subdural hematoma. They stated that "on the whole a generous exposure of the lesion by an osteoplastic resection, without or with a combined subtemporal decompression to accommodate the subsequent edema, seemed to be the preferential method." They reported one patient successfully treated by means of a burr opening in the course of a ventriculogram. They suggested that the neomembrane over the arachnoid need not be removed, that a small drain does no harm and oozing may demand its use. The observation was made that the brain usually expands, but failure may result in a fatal outcome as observed earlier by Trotter. In 1927 Rand reported several cases of chronic subdural hematoma and emphasized the importance of evacuating the hematoma regardless of the type of procedure used to accomplish this. He stated, "while an osteoplastic flap and removal of the hematoma, both the linings and contents as suggested by Putnam may be the method of choice, it is felt that a procedure such as decompression with evacuation and simple trephining and aspiration of the contents of the hematoma will yield good results." He noted that the sac containing the hematoma did not refill after evacuation and suggested that allowing the lining membranes to be undisturbed did not influence recovery.

In 1932 Fleming and Jones reported upon a simple drainage as a method of treatment for chronic subdural hematoma, reviewing eight cases which were treated by means of trephine openings. They stated the method briefly "is to make under local anesthesia, four trephine openings in the frontoparietal and parieto-occipital region on either side. The incisions are so fashioned and the openings so placed that they may be incorporated in an osteoplastic flap at a subsequent date if this is necessary. Small openings made in the dura expose the sac of the hematoma which is torn open, allowing the contents to escape. This is followed by through and through irrigation of the sac with Ringer's solution. The scalp incisions are closed without drainage." They reported several advantages to this procedure, one of which was that a relatively minor procedure was substituted for a formidable operation. They emphasized the advantage of bilateral exploration. The time required for this procedure was short and they thought the use of this method was warranted in place of "the accepted and more radical procedures." They realized, however, that "the method of simple drainage is open to criticism since incomplete removal of pathological material is not an accepted surgical principle." It is of note that this method was suggested in the treatment of chronic subdural hematoma, which by virtue of its fluid content could be evacuated through trephine openings in a high percentage of instances. The adaptation of this method to the acute and subacute types of hematoma soon followed.

In 1935 Coleman suggested, "single or bilateral trephine openings in the upper temporal region under local anesthesia offer perhaps the only method of recognizing many of the acute clots in time to save the patient." He emphasized the importance of this method

for "certifying the diagnosis in doubtful cases showing signs of pressure." He noted, "if either a subdural clot or fluid collection was found, very little if any additional exposure is necessary to eradicate the lesion." He stated, "an osteoplastic flap is never required as a primary procedure unless a burr opening shows a solid clot and this is unusual. As a secondary procedure it may be needed to remove solid portions of clot not evacuated through the small bone opening." There was no reason to believe that the retained sac would produce any complication.

Kennedy and Wortis in 1936 reported favoring the use of trephine openings in the management of the subdural hematoma. They stated, "it had been noted that the trephine approach to the subdural hematoma may result in an incomplete removal of the entrapped blood." The blood remaining in the subdural space might act as a "nucleus for the reformation of another clot." In two patients in which a non-total removal had been done with subsequent death from other causes, it was noted that in neither case had there been a reaccumulation of the hematoma. They reported that if a clot was found to be too solid to be removed by suction which was held to be a rare occurrence in acute subdural hematoma, the trephine opening could then be used as a point for making a bone flap.

Munro has found that the treatment of the acute hematoma is satisfactory by means of a transtemporal approach which may or may not include a subtemporal decompression. If more room is required for the control of hemorrhage, a wider opening should be made in the bone and in the dura. He stated that the bone flap procedure is too formidable an operation for the patient with a head injury and that irrigation of the subdural space does not remove all the clot. He recommended drainage for forty-eight hours with a rubber tissue drain. He found that the treatment of "older cases" is somewhat less difficult. He stated, "if a solid clot is suspected, and the patient's condition is such as to justify the procedure, a bone flap craniotomy may be performed. My experiences have been, however, that even here the operator and the patient are both better off in a majority of cases if the transtemporal approach is used." Munro found that as a class, subdural hematomas occur in about 18 per cent of all craniocerebral injuries and that the mortality for this group should not be over 35 per cent.

King reported his experience in 1943. He found that multiple burr openings may be necessary in the localization and removal of the clot. He emphasized that in every instance bilateral burr holes should be made. He advised that if the clot were solid, the opening should be enlarged to the size "approximately of a silver dollar, and the incision of the dura be lengthened." By so doing the solid clot can be readily and thoroughly removed by suction under direct vision. After the evacuation of the clot the dura was recommended as being loosely closed with drainage inserted in the subdural space for a period of twenty-four hours. If a chronic subdural hematoma were encountered after making routine bilateral burr openings in the upper temporal region, King advised, "since this type of clot cannot be properly removed through a simple burr hole, and since the bony opening would have to be enlarged to undesirable portion, I have preferred making a bone flap through a straight or slightly curved horizontal incision."

From a wide experience, Browder found that "it is unwise and unsafe to attempt removal of hematomas, be they epidural, subdural or intracerebral through the traditional subtemporal decompression. If the subdural collection is not entirely liquid and cannot be evacuated through two small openings, then it is preferable to utilize a small bone flap made over the site of the lesion."

Echlin followed a plan of procedure which included "aspiration for all subdural hematomas through the bilateral temporal approach." He stated, "with the patient in a semi-sitting position, supported by a small, posterior neck rest, a burr opening is made anterior to and above each ear." The patient is draped so that a subtemporal decompression and occipital burr holes for ventriculography could also be carried out if necessary. When a semi-solid clot was found, it was evacuated by enlarging the subtemporal decompression. He stated, "when exploration through the temporal approach fails to reveal a hematoma, it is obvious that additional burr holes may be indicated." He found that it was necessary to turn a bone flap in only one case of a series of seventy.

Evans has reported that he deals with

FIG. 1. The pattern in subdural hematoma. Note marked shift of the anterior cerebral to the right. A 200 cc. liquid subdural hematoma was found in this case.

acute subdural hematoma and the epidural collection in much the same fashion. The entire head is draped so that burr openings may be placed at will. Initial openings are made in the subtemporal region bilaterally. If a subdural collection is found, evacuation may be possible through this single opening, or "it may prove wise to place additional frontal and occipital openings so that washing may be done from opening to opening." Frequently, a catheter is used to explore beyond the limits of vision, "gently forcing saline solution into the catheter and watching the washings for signs of clot." At times it may be necessary to enlarge the subtemporal opening in order to evacuate the more solid clot manually with the aid of a brain spoon. Only rarely was an osteoplastic flap found to be necessary. In treating the chronic subdural hematoma, Evans reported that "we generally begin with bilateral occipital openings. Should the clot not be found, bilateral frontal and bilateral temporal openings are made. If all these openings fail to reveal a clot then ventriculography must be resorted to. Only rarely has it been found necessary to reflect a bone flap in order to evacuate this lesion."

Recently Chambers, in dealing with the acute subdural hematoma, has found that a suitable plan of management is the use of a temporal opening just below the insertion of the temporal muscle. If a massive subdural clot is encountered and there is persistent bleeding, which he points out often occurs at the base from the inferior cerebral veins, then "a curved incision is carried posteriorly above and behind the ear and depending upon the patient's condition, and the rapidity of blood loss, either a small bone flap can be turned down, hinged on the temporal muscle, or if speed seems essential, the muscle is stripped downward from the bone and the bony defect is rapidly enlarged with the rongeur."

By this partial review of the modern literature, it becomes evident that a variety of methods are used in the treatment of the subdural hematoma and that standardization of the surgical management has not developed. This observation does not apply to the epidural hematoma of middle meningeal origin. This lesion has been successfully dealt with by means of a subtemporal decompression in most instances, or the use of a small bone flap when the lesion is accurately diagnosed preoperatively. Nor does it apply to the intracerebral hematoma, the treatment of which has evolved into an aspiration through a single opening, followed by a bone flap operation as indicated.

Subdural hematoma is a more complicated lesion by virtue of its pathophysiologic qualities which include its variable location, the degree of solidity or fluidity of its contents, its size, its age, its bilaterality, and its unpredictable dynamic effect. These factors, and particularly the uncertainty involved in the diagnosis of the subdural hematoma due to masking associated intrinsic brain damage, may account for the many variations employed in surgical treatment. (Fig. 1.)

The early management employed the trephine and later burr openings for diagnostic purposes. Once identified, the lesion was then in the early part of this century treated by the customary use of an osteoplastic craniotomy which was quite reasonable. The objection was then made that this operation was too formidable for the sick head injury patient. In 1932 Fleming and Jones found that it was

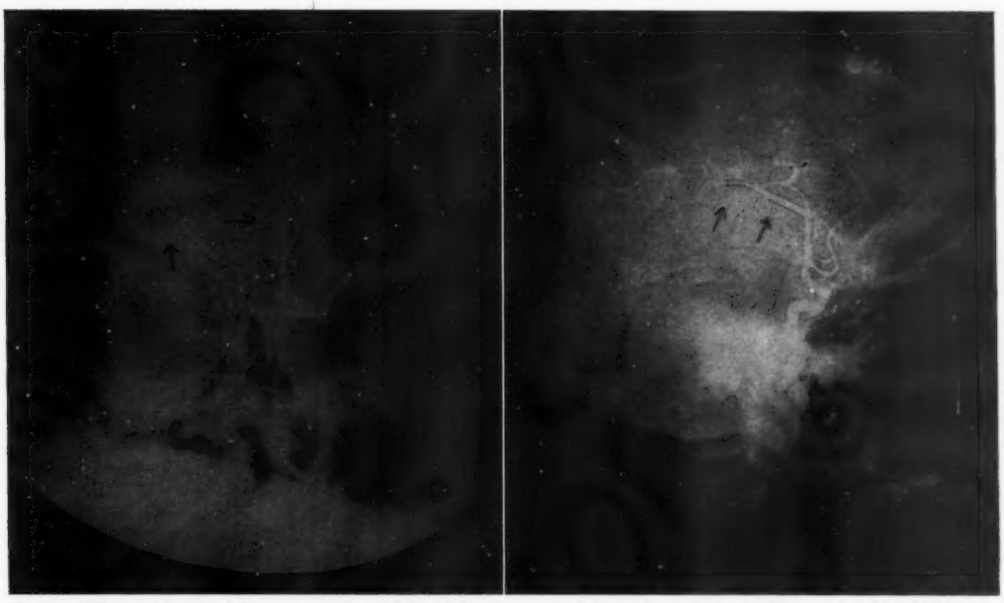

FIG. 2. The angiographic pattern in epidural hematoma. Note that the middle cerebral is definitely elevated and the anterior cerebral is shifted past the midline. Temporal lobe lesion can be surmised. This was a 100 gm. epidural hematoma.

possible to treat the chronic subdural hematoma by means of drainage through a diagnostic opening and this was confirmed by others. The same plan of burr opening evacuation was then applied to the more acute varieties of hematomas, although initially, such a method was designed only for the chronic subdural extravasation the contents of which were fluid and permitted drainage through simple burr openings. This adaptation may be accounted for by its simplicity, its time-saving advantage and its tolerance by the patient. It offered a simple, short procedure as a last resort measure often in a desperately sick patient. A common attitude on the part of the surgeon has been that it is better to have trephined and lost the patient than never to have trephined at all. An operation through burr openings satisfied the diagnosis, encouraged the feeling of "having given the patient every chance." The resulting high mortality was accepted as not unusual in view of the circumstances involved in the patient's disease.

Several other surgical methods have also been found to be of practical value. These included enlarging the burr opening after the diagnosis had been made to allow sufficient room for evacuation of a solid or partially clotted hematoma. A subtemporal decompression has been used routinely regardless of the boundaries of the hematoma. An osteoplastic flap constructed about the diagnostic openings is also a common method. There is no evidence to indicate which of these methods is preferable.

Standardization. With angiography (Figs. 2 to 4) it is possible in an important number of cases to establish the diagnosis and localize the extravasation whether it be epidural, subdural or intracerebral prior to surgical treatment. The surgical treatment can then employ the most suitable method for evacuation of the lesion. The following are patterns which indicate types of extravasations one may encounter as shown by angiographic studies. These studies employ diodrast or thorotrast as contrast media. Thorotrast is usually routinely used in patients above fifty years of age. Whenever possible, the angiogram is done under local anesthesia. At times, however, pentothal anesthesia® becomes necessary in the restless patient. The percutaneous method is used for the injection. Survey roentgen studies are first made with the patient always supine. The angiographic study follows. If a lesion is identified, the patient is immediately removed to the operating room for evacuation of the collection. If the wrong side is injected as shown by the displaced anterior cerebral artery, the opposite side is injected. In a posterior fossa collection, the angiogram

FIG. 3. The pattern of temporoparietal intracerebral hematoma. There is shift of anterior cerebral and elevation of the middle cerebral.

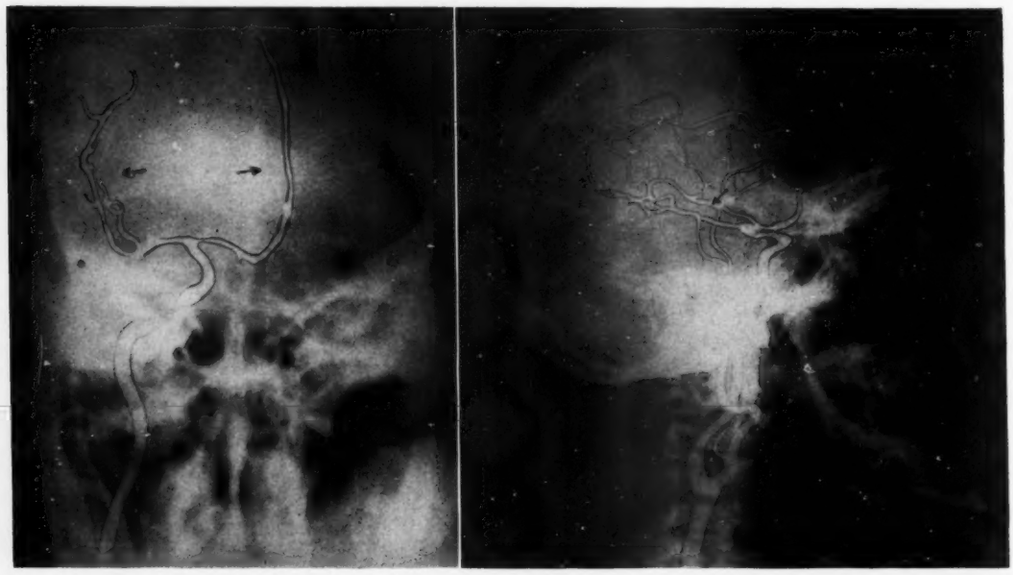

FIG. 4. Frontal lobe intracerebral hematoma. Note the separation of the anterior and middle cerebral group of vessels by the clot in the anteroposterior view, and the middle cerebral depression in the lateral view.

is normal. Surgical treatment must be decided on the basis of clinical signs and a posterior fracture site. Any doubt concerning the presence of an occipital or parieto-occipital lesion must be settled by a burr opening. These are uncommon circumstances.

A standard technic may then be used in dealing with the subdural hematoma, the lesion having been localized before operation. Since the simplest method is usually the best method, a preliminary burr opening may be made to establish the fluidity of the collection. If the collection is fluid, a counter opening may then be used to complete the evacuation. If the collection is established as being solid and unsuitable for evacuation through simple

burr openings, the most suitable means of opening the skull at the site of the lesion should be employed. This has proved to be an osteoplastic craniotomy. This operation has the important advantage of avoiding the production of a bone defect. It is also a much less formidable operation than it was in the early evolution of treatment. When the angiogram is normal, that patient is returned to bed and an unnecessary operation is then avoided.

SUMMARY AND CONCLUSIONS

During the past year we have found that the following steps taken with the injured patient suspected of an intracranial extravasation of blood of surgical proportions resulted in an efficient management:

1. A detailed neurologic examination was made in a search for focal signs and evidence of increasing intracranial pressure.

2. A spinal puncture was routinely performed, the pressure and the degree of bloodiness of the fluid recorded.

3. Routine roentgen studies of the skull were made.

4. When any doubt existed as to the presence of a complicating intracranial collection, with the patient remaining on the x-ray table, an angiogram was made.

5. If the contrast study revealed a lesion, operation was immediately carried out by a standardized procedure, since the site and type of lesion was usually identified beforehand.

6. If no lesion was present, the patient was returned to bed for conservative care.

These steps in management will uncover subdural, epidural and intracerebral collections in the more forward portions of the head. Occipital and cerebellar hematomas are still serious diagnostic problems.

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TRAUMATIC VASOSPASM AND ITS COMPLICATIONS

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PRIMARILY this article is proposes to illustrate that vasospasm following trauma is not always an innocuous and fleeting affair, but depending upon its severity and duration, may produce Volkmann's contracture, necrosis of the muscles or even gangrene of the entire limb.

Secondly, in the cases about to be presented many types of treatment were tried and all failed, and we are most anxious to hear whether some of you have had similar experiences and have been able to overcome this perilous lesion.

CASE REPORTS

CASE 1. A French-Canadian soldier, twenty years old, while up a tree during battle exercise, was shot in the right thigh from below. He was admitted to No. 1 Canadian General Hospital eight hours after his injury. He was not suffering from shock, his blood pressure being 120/80. In accordance with our custom he was x-rayed and no foreign body was seen. A blood transfusion was started, an anesthetic was given and his dressings were removed. Two large communicating wounds were seen, both about 5 inches above the knee. Between them the vastus lateralis and intermedius had been blown away and the lateral surface of the femur exposed. The short head of the biceps formed the medial aspect of the wound and was undisturbed. The sciatic nerve was not seen. A thorough excision was done, sulfanilamide powder dusted in, the wound was packed lightly with gauze, no sutures were inserted, and a closed plaster applied following the Trueta method. The patient returned to the ward in excellent condition and that night was quite comfortable and happy.

The following day the patient looked well, temperature and pulse were normal, but he complained bitterly about pain in the leg and inability to move his toes. On testing he was insensitive to pain or touch. There was no swelling or blueness of the toes and they were not cold, but on his insistence the cast was cut down. This relieved him for a few hours but the pain returned with redoubled intensity.

Accordingly, the cast was removed. The toes were not swollen, blue or cold but there was an area on the medial aspect of the great toe, suggestive of commencing gangrene. There was no sensation and no active movement of toes, foot or ankle. Posterior tibial and dorsalis pedis pulsation were absent on the right side and the posterior tibial pulsation was absent on the left.

The calf was swollen, stony hard but not edematous as if there had been a large hemorrhage into the deep structures. It was exquisitely painful. The site of the wound was not painful and there was no evidence of infection. The femoral artery was pulsating normally and the popliteal was also felt.

A diagnosis of early Volkmann's contracture was made and it was decided to explore the popliteal space to see whether the vessel had been damaged.

The patient was anesthetized, turned on his face and the popliteal space laid open by a midline incision. The vessel was found to be pulsating quite normally. The incision was then extended down the calf of the leg and as the aponeurosis was divided, the calf muscles literally burst out of their retaining sheaths. They were brownish red in color, dry in texture, and bled hardly at all. The posterior tibial vessel was then exposed just above the ankle and was found to be no larger than a thread, in tight spasm, and not pulsating. It was followed upward and as the retaining fascia of the deeper muscles was divided, they resembled in every way the appearance of those more superficial. Although originally we had been able to feel the vessel pulsating just above the point at which we exposed the lower end, as we followed it upward it went into spasm as we touched it. This process continued like a mirage in the desert until we reached our original point of entrance at the lower end of the popliteal space. Here, too, the same process was repeated and although we could feel the vessel just above pulsating vigorously, the part exposed to our eyes was now contracted to the size of a knitting needle and remained pulseless. We gave papaverine without any noticeable change. We injected acetyl choline into the vessel without effect, but we were able to ascertain that there was a tiny stream of blood passing down the lumen. We next proceeded to do a periarterial sympathectomy and this had no result. A spinal anesthetic was then given without result and so we gave up and closed the wound. We considered doing an arterectomy but thought it would be useless as we had no idea where to do it; and as there was a tiny stream of blood flowing down the posterior tibial, we believed it might even be detrimental.

Following the operation his foot was cold and

mottled. On the day after it looked much as it had before the operation. He complained of loss of vision in his right eye and our ophthalmologist found a small hemorrhage or thrombosis of his retina.

For thirteen days we remained indecisive. The leg was dressed several times and it was obvious that the calf muscles were melting away. No movement or sensation returned to the foot nor was any pulsation felt, but the extremity remained warm and showed no signs of gangrene. Finally, secondary infection supervened and it was thought unwise to jeopardize the man's life for a useless member.

Therefore, a supracondylar amputation was done. The femoral artery and vein appeared perfectly normal. The sciatic nerve, as we pulled it down to divide it, showed on its lateral surface where it passed close to the original wound, a greenish, mottled appearance as would occur from a resorbing hemorrhage. The nerve was cut off and did not bleed. The stump was left open. The patient subsequently made an uninterrupted recovery.

The leg was thoroughly dissected. The muscles in both the anterior and posterior compartments had undergone the same process; they were all a greyish green mush. The plantar muscles of the foot, on the contrary, had not degenerated but appeared white to pink, looking like fish flesh. The main artery vein and nerve were removed in one piece from the site of amputation to the ankle.

Pathologic examination of the calf muscles showed in some areas completely degenerated muscle in which only vague outlines of fragmented fibers remained. In other areas there was frank suppuration with dense masses of acute inflammatory cells.

The whole picture was one of muscle infarction with, in certain areas of the calf, the added picture of infection. This certainly would appear to resemble the pathologic picture of a Volkmann's contracture.

The sections of the artery, vein and nerve showed the artery and nerve to be normal at all levels. The sciatic nerve showed a resorbing hemorrhage within it.

Case II. This soldier, age twenty-five, was admitted with a simple comminuted fracture of the middle third of the left tibia and fibula. While in traction in a Bohler frame under anesthetic he developed convulsions, which were thought to be due to ether. These were finally controlled by pentothal® and he was left in traction.

Four days later the toes were swollen and blue. No pulsation of dorsalis pedis or posterior tibial was palpable. There was no sensation and no movement. Assuming this to be due to vasospasm a spinal anesthetic was given. There was no improvement in circulation. Papaverine was also tried without effect. It was noted there was much swelling and blistering at the site of fracture. There was a slow development of gangrene of the toes and of the skin overlying the fracture. With the onset of secondary infection, amputation below the knee was performed.

The muscles throughout the leg were pale, greyish pink and soft, with the fish flesh appearance typical of Volkmann's contracture.

The vasospasm in this case was originally thought to be due to the irritation of the vessels by the rough bone ends occurring during convulsion, but no damage to the vessels was found by the pathologist on serial section.

Case III. A young soldier suffered a simple fracture of his humerus while on battle exercise. On entering the C.C.S. his arm was cold and pulseless and it was assumed that the end of the bone was pressing on the brachial artery. Accordingly, the brachial artery was exposed and a point on it was seen which might have been damaged. However, despite various local treatments, the pulsation did not return.

Accordingly, this area of the artery was excised but the spasm persisted, gangrene ensued and amputation was later done. Examination of the vessels showed no organic lesion.

Case IV. A boy of twelve fell from a tree and sustained simple fracture of the clavicle. The arm became cold and pulseless within twelve hours, and despite cervical blocks and other forms of treatment, gangrene ensued. Again, subsequent examination of the vessels revealed normal structure throughout.

Case V. A soldier sustained a bullet wound of the left thigh, severing the vessels and subsequently requiring amputation. While in the hospital his right arm became cold and pulseless, and he developed all the signs and symptoms of Volkmann's contracture although he had sustained no known injury to this arm. Although the arm was useless, he refused amputation.

Case VI. A young soldier sustained a gunshot wound of the right side of the neck, and was admitted almost unconscious, dyspneic and showed left-sided hemiplegia. Emergency tracheotomy was done but no other operation was performed. He remained hemiplegic and died two days later. At autopsy, no head injury was found. On exploration of the neck, there was a wound of the superior thyroid artery extending approximately to the external carotid but not involving it. The common, internal and external carotid arteries were completely normal and no thrombosis could be found after a complete search of the base of the skull and into the brain. The right hemisphere was swollen, purplish and showed petechial hemorrhages. Here then is a patient with no wound, thrombosis or embolism of the major arteries, whose condition can only be explained on the basis of a carotid spasm.

The evidence would seem sufficiently complete to conclude that: (1) Spasm of the vessels either alone or combined with an organic lesion, depending upon the degree and duration of ischemia which occurs, may produce Volkmann's contracture, necrosis of the muscles or gangrene of the limb. (2) In our hands the treatment of certain severe cases of spasm has been wholly unsatisfactory. (3) Volkmann's contracture is not a separate entity but merely a stage between the complete recovery of the limb and total gangrene, the muscles perishing because of their great need for oxygen.

Finally, with many doubts and no experimental proof, we suggest that this vascular spasm may arise as a result of a reaction of the whole organism to emotional disturbance possibly acting through the endocrine system and that the trauma is merely a local trigger mechanism. This theory is supported to some extent by cases of juvenile gangrene described by Homans, Kroh and Martin, where a limb has perished without any demonstable trauma, and also by the fact that spasm may persist although all the nerves to the limb are actually or functionally severed. We suggest, therefore, that as local treatment has been so unsatisfactory, it might be well to widen the scope of our investigations and seek an answer in a general rather than a local remedy.

Acknowledgment: We wish to thank Drs. Luke, Armour, Robertson and MacNaughton for their permission to mention their cases.

TRAUMATIC ARTERIOVENOUS FISTULAS AND ANEURYSMS IN WAR WOUNDED*

A STUDY OF 101 CASES

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AFTER the outbreak of Korean hostilities, as in World War II, certain hospitals were designated by the Surgeon General's office as specialty centers. In accordance with the program, Walter Reed Army Hospital was designated as a vascular center and has since received and treated over 100 arteriovenous fistulas and false aneurysms. The management of arteriovenous fistulas and false aneurysms, which includes principal findings of systemic and local effects of the lesions, is the subject of this report. This study is based on the findings in 101 patients with 106 arteriovenous fistulas and false aneurysms. These Korean injured were received from two weeks to one year after injury. The long delayed arrivals were cases in which the diagnosis may have been overlooked at earlier dates or in which lesions may have developed later. Of these 106 lesions the ratio was found to be approximately two arteriovenous fistulas to one false aneurysm. (Table I.) This is consistent with the findings of others in World War II.

An arteriovenous fistula is an abnormal communication between an artery and a vein which results from an injury to those vessels. Such a fistula may or may not be associated with a sac. If a false sac exists, some have termed this a varicose aneurysm or an arteriovenous aneurysm. For purposes of clarity, the term arteriovenous fistula will be used to include all variations of this type of lesion.

A false aneurysm results from the rupture of all the component parts of a portion of the arterial wall. The resulting sac in continuity with the arterial wall contains laminated clots and arterial blood.

The differential diagnosis between fistulas and aneurysms usually is not difficult. In both a pulsating mass is often present. In arteriovenous fistula a thrill is always present, and in the great majority of cases it is transmitted along the course of the involved vessels. On auscultation a loud, continuous, machine-like murmur is heard. This murmur is intensified during systole. False aneurysm differs in that there is no diastolic component to the murmur and the murmur is rarely transmitted beyond the region of the aneurysmal dilatation. Thrill is present in false aneurysms only inconstantly, and it is usually less distinct than in arteriovenous fistula. Figures 1A and B show stethograms of the sound produced by an arteriovenous fistula and a false aneurysm.

TABLE I*

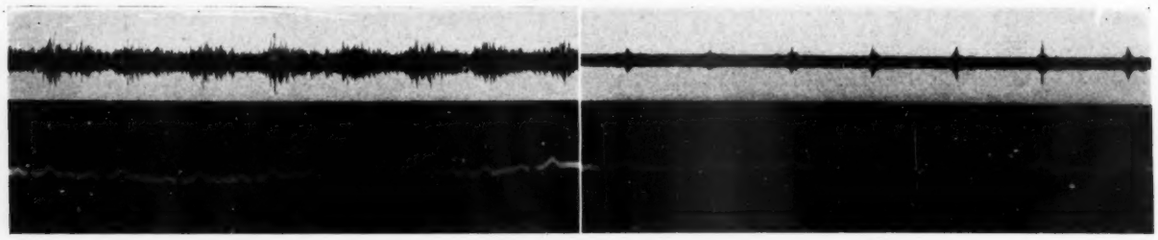
	No.	Percentage
Arteriovenous fistulas	73	68.8
False aneurysms	33	31.2
Total	106	100

* The percentage of arteriovenous fistulas is almost two times that of aneurysms which is consistent with World War II findings.

MANAGEMENT

Based primarily on the World War II experience of one of us (Elkin), surgery in all uncomplicated cases arbitrarily was delayed three months from the time of injury. The relationship of time to the development of collateral circulation in vascular injuries is a controversial subject which this presentation will not attempt to settle. Although the time element for adjustment may be shorter than three months, it

* From the Walter Reed Army Hospital, Walter Reed Army Medical Center, Washington, D.C. Published under the auspices of The Surgeon General, United States Army, who does not necessarily assume responsibility for the professional opinions expressed by the authors.



1A 1B

FIG. 1. A, The upper tracing is a sound tract tracing of the murmur heard in an arteriovenous fistula. Note the continuous sound accentuated in systole. The lower tracing is an electrocardiogram tracing. B, the upper tracing is a sound tract tracing of the murmur heard in a false aneurysm. Note that the murmur exists in systole only. The lower tracing is an electrocardiogram tracing.

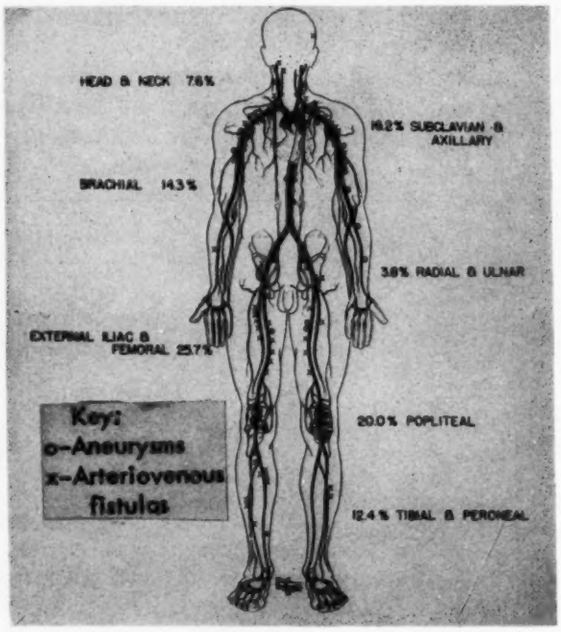


FIG. 2. The vascular injuries were distributed as shown by this chart. Note the high incidence in the popliteal area.

will be demonstrated by the results as shown in this report that three months has been a safe period in our series. During the preoperative phase of management studies were done (1) to determine the local effects of the arteriovenous fistula or aneurysm and (2) to determine the systemic effects of the lesions. Since the altered physiology calls forth compensatory changes which continue to develop over a period of time, it became necessary to repeat the function and laboratory studies at specified intervals. In general, a complete work-up was obtained on a patient as soon after admission as possible. These procedures were repeated three months postinjury or immediately before definitive surgery, and again one month postoperatively, except in a few instances in which emergency surgery was required on or shortly after admission.

The following criteria were used to determine the local effects of arteriovenous fistulas and aneurysms: pulsations below the lesion; color of the skin, ulcerations, pallor and blanching; size of the extremity and the extent of edema; oscillometric readings; skin temperature readings and reactive hyperemia times.

The following procedures were applied to ascertain the systemic consequences of arteriovenous fistulas and aneurysms: (1) blood volumes as measured by parallel studies with radioactive human serum albumin and the Evans blue dye method; (2) cardiac outputs as a simultaneous study of blood volume by dye dilution curves and radioactive human serum albumin; (3) cardiac silhouette measurements; (4) Branham's phenomenon which is the decrease in heart rate on occlusion of an arteriovenous fistula; (5) electrocardiograms; (6) systemic circulation times as measured by decholin arm to tongue time and (7) blood pressures and pulse pressures.

In Figure 2 is graphically portrayed the location of all the vascular lesions encountered in this series. The lesions ranged from the superficial temporal artery to the deep plantar arch. The vessels of the lower extremity received most of the injuries, with the popliteal artery the most often involved. Injuries to the upper extremity vessels were next most common while there were fewer injuries to vessels of the head and neck. Table II shows the number and locations of various lesions.

Local Effects of Arteriovenous Fistulas and False Aneurysms. The local effects of arteriovenous fistulas or aneurysms are those associated with some degree of arterial insufficiency. The skin changes vary in degree in proportion to the inadequacy of the circulation. Some

limbs exhibited ulcers, rubor, cyanosis, enlarged veins, coldness, edema and other evidence of poor circulation. Note the enlarged veins in Figure 3. Subjective symptoms include paresthesia, burning, and prickling, cold sensitivity, weakness, easy fatigability and claudication. Serial oscillometric and skin temperature readings were of aid in evaluating changes in circulation of the affected extremity, including increase in collateral circulation. The reactive hyperemia test was especially valuable and often gave a good estimation of the extent of the collateral circulation. Pulses distal to lesions were observed carefully. In a limb containing an aneurysm but showing adequate circulation, a poor or absent pulse was considered indicative of good collaterals. If pulses became weaker in the presence of enlarging lesions, surgery was performed without delay. The limbs and lesions were measured and continued enlargement of lesions was also an indication for immediate surgery.

TABLE II*

Location	Arteriovenous Fistulas	False Aneurysms	Total
Head and Neck			
Superficial temporal	1	0	1
Vertebral	1	0	1
Thyroid	2	1	3
Common carotid	3	0	3
Internal carotid	1	0	1
Upper Extremity			
Subclavian, axillary and branches	10	8	18
Radial	0	2	2
Brachial and branches	6	7	13
Lower Extremity			
External iliac, femoral and branches	24	5	29
Popliteal and branches	13	9	22
Tibials and peroneal	11	1	12
Plantar	1	0	1
Total	73	33	106

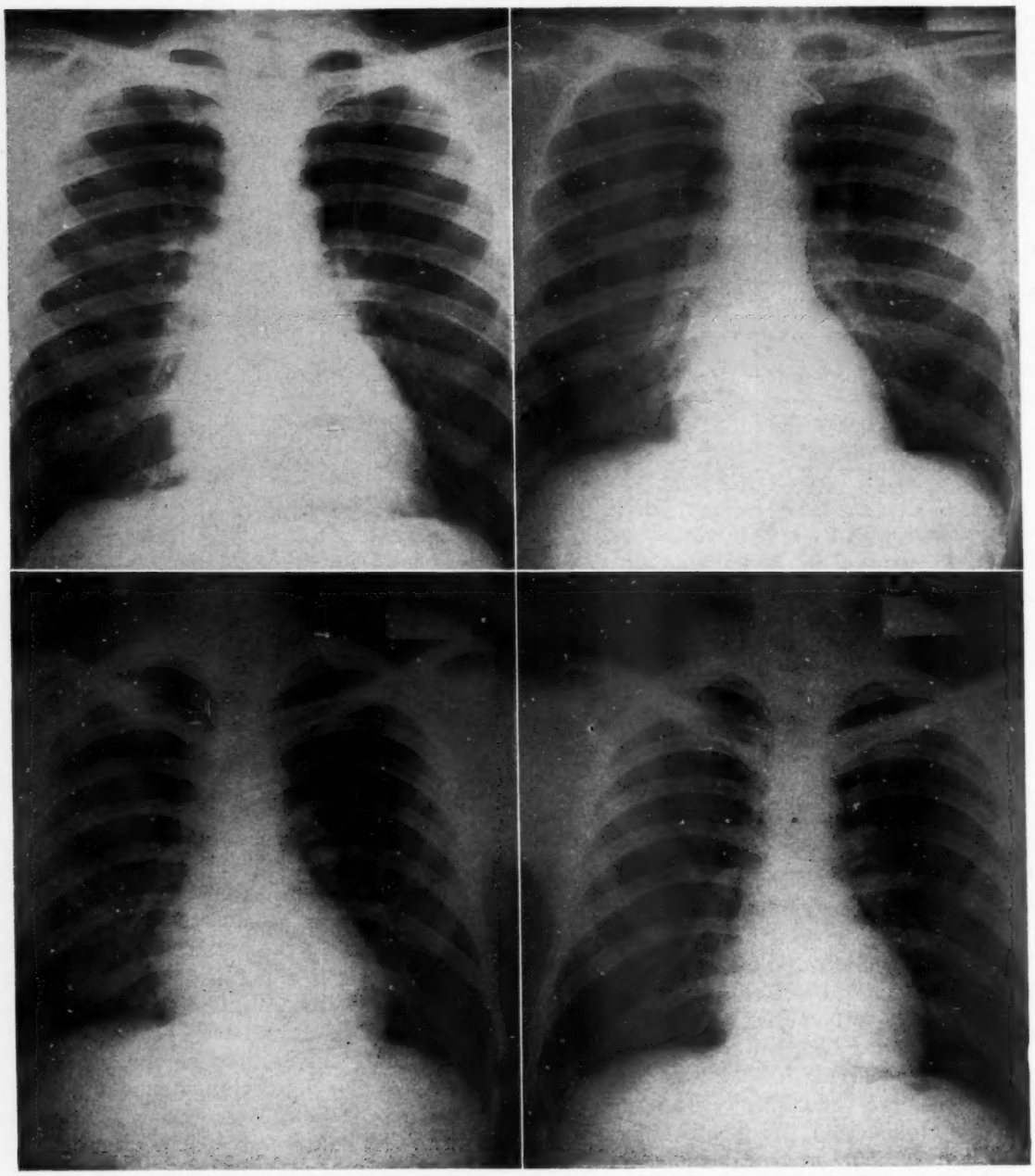
* The general distribution of fistulas and aneurysms is shown by areas.

Systemic Effect of Arteriovenous Fistulas and Aneurysms. There were no systemic effects noted in cases of false aneurysm. In the arteriovenous fistulas the systemic effects, in general, varied in proportion to the size and duration of the shunt. Pulse pressures, cardiac output and blood volumes were increased. In several patients the cardiac silhouette was significantly increased in size. (Figs. 4A and B and 5A and B.) Following surgical repair of the fistula heart size returned to within normal limits. Branham's phenomenon was present in most of the cases, the pulse rate decreasing as much as fifty-two beats in one case. This sign was also useful in the differential diagnosis of arteriovenous fistulas and aneurysms. The electrocardiograms showed no changes relative to the vascular lesions. Systemic circulation time using decholin was not considered an accurate test because of patient error.

FIG. 3. Venous dilatation is evident in the presence of a large axillary arteriovenous fistula. The bulging of the false sac is evident just below the clavicle.

FALSE ANEURYSMS

In our opinion the traumatic false aneurysms were the most difficult to manage. The tendency of these lesions to enlarge was a constant source of concern. (Figs. 6A and B.) It became necessary to operate on eight occasions as emergency procedures because the lesions of the false aneurysms were expanding. In two instances operation was performed because extension of thrombi from the large aneurysmal sac occluded the artery distal to the aneurysm.



4A 4B

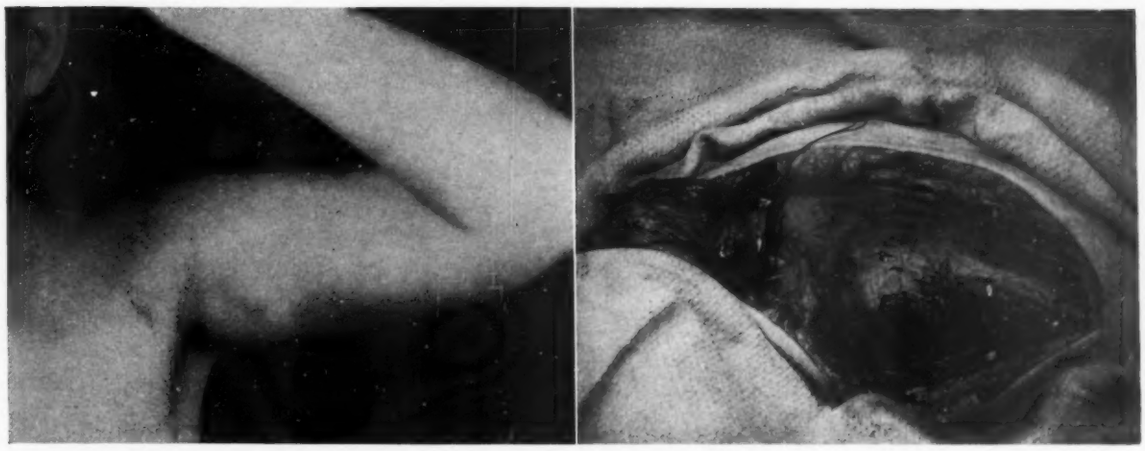
5A 5B

FIG. 4. A, The preoperative heart size is compared with the postoperative heart size in the case of a large arteriovenous fistula of the common carotid and internal jugular vessels of three months' duration. B, postoperatively the heart size has returned to within limits.

FIG. 5. A, This cardiac dilatation occurred in a patient with a superficial femoral arteriovenous fistula of six months' duration. B, postoperatively the heart size has decreased to within normal limits.

Expansion of arteriovenous fistulas is usually not a problem because the blood is readily shunted from a high pressure area in the artery to a low pressure area in the vein. However, a large aneurysmal sac in conjunction with an arteriovenous fistula may also expand. (Fig. 7.) We have been forced to operate in five cases of arteriovenous fistulas with expanding false sacs.

In the group of cases including the ninety operated upon and the four spontaneous closures of the lesion (Table III) there were sixteen with associated disabling nerve or bone injuries. Of the remaining seventy-eight, all but



6A 6B

FIG. 6. A, The enlargement of this axillary aneurysm required emergency surgery soon after admission. B, at surgery the break in the wall of the false aneurysm is seen.

four have returned or will be returned to duty. Three of the four are on limited duty, with chronic venous insufficiency, due to a major vein ligation. One patient with ligation and excision of a popliteal arteriovenous fistula had arterial insufficiency and was retired.

TABLE III*

Operated cases	90
Spontaneous closure	4
Cases awaiting operation at the time of this report	7
Total	101

* The total number of patients with vascular lesions is shown with the number operated upon and the number closed spontaneously.

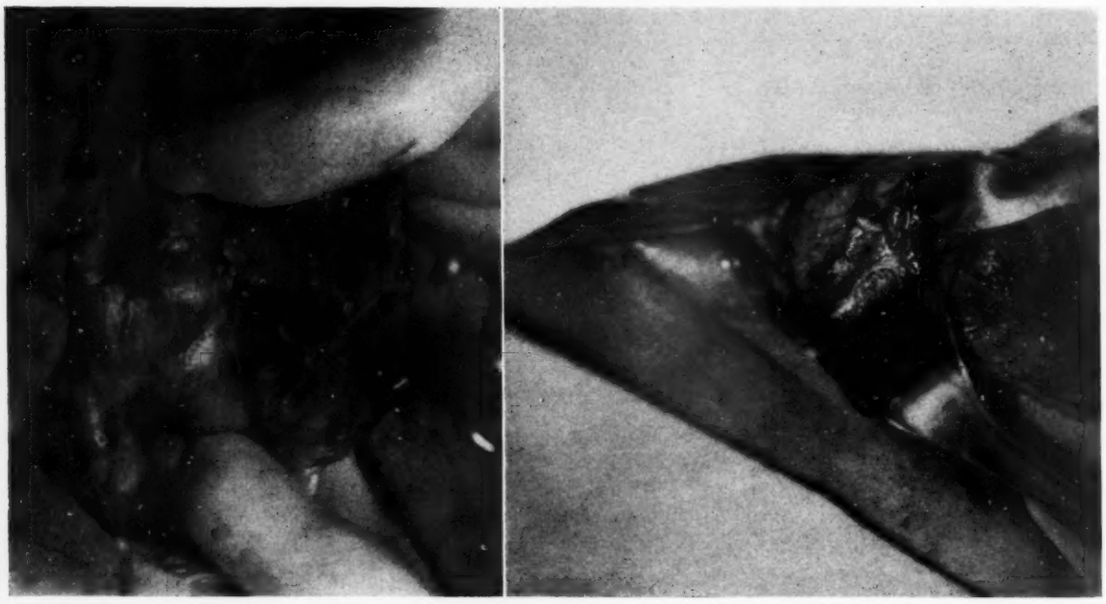
Arteriovenous fistulas and aneurysms involving smaller vessels are of interest only because of operative approach and surgical technic. They presented none of the problems encountered in the major vessels where re-establishment of blood flow to an extremity was necessary for its preservation and function. Accordingly we will confine most of this discussion to management and operative results of the major vessels.

COMMON AND INTERNAL CAROTID ARTERIES (FOUR CASES)

Operations have been performed in three of four cases of carotid lesions. There were three cases of arteriovenous fistulas between the common carotid artery and the internal jugular vein, two of which have been operated upon. In both cases blood flow was re-established by excision of the fistulas and end-to-end

FIG. 7. The enlargement of the thigh resulted from a false sac connected with an arteriovenous fistula of the superficial femoral artery. The sac enlarged requiring immediate surgery and at surgery the sac held 1,500 cc. of blood and clot. Daily measurements are marked on the leg in ink.

anastomosis of the artery. In both instances the jugular veins were also repaired, one by ligation across the fistulous tract adjacent to the vein and the other by interrupted suture repair of the damaged vein wall. These two cases have excellent pulsations in the superficial temporal arteries and no disability attributable to the fistulas or the surgery. (Figs. 8A and B and 9.) In the fourth case a communication existed between the internal carotid and an unidentified vein at the base of the skull. The artery and vein were successfully ligated and the patient has no residual. These three patients have been returned to military duty.



8A 8B

FIG. 8. A, The arteriovenous fistula between the common carotid artery and internal jugular vein is exposed by the fingers retracting the greatly distended vein. B, the common carotid artery anastomosis is shown following excision of the fistula.

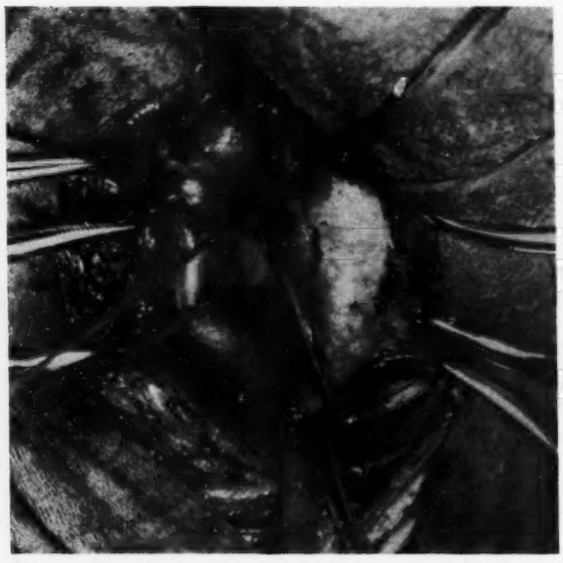


FIG. 9. An arteriovenous fistula between the internal jugular vein and common carotid artery is exposed by a tape about the fistulous tract.

FIG. 10. A brachial artery aneurysm is demonstrated. The retracted nerve also shows evidence of injury.

SUBCLAVIAN, AXILLARY AND BRACHIAL ARTERIES (TWENTY-SIX CASES)

Twenty-four patients in this group have been operated upon. The other two patients are awaiting surgery. Twelve of these had traumatic false aneurysms (Fig. 10) and twelve had arteriovenous fistulas. (Fig. 11.) Continuity of the vessels was re-established in twelve of these cases by graft or artery repair and excision and ligation was performed in twelve cases. (Table IV.) All but one of the reconstructed group have excellent pulsations distal to the site of injury, and all have good functional results. One vein graft to the axillary

TABLE IV*

Excision and ligation	12
Repair of artery by suture	8
Autogenous vein graft	1
Homologous artery graft	3
Total	24

*Of the twenty-six patients with subclavian, axillary and brachial artery injuries admitted thus far, twenty-four have been operated upon as shown above.

artery has only fair peripheral pulsations. Five had associated disabling nerve injuries. Sympathectomy was done in eleven cases for causalgia or associated nerve injury. The remaining nineteen have been or will be returned to duty.

EXTERNAL ILIAC AND COMMON FEMORAL ARTERIES (SEVEN CASES)

Operation was performed upon one false aneurysm and three arteriovenous fistulas in this group while three patients with arteriovenous fistulas are awaiting surgery. Continuity of the vascular channel was established in all four cases. An autogenous vein graft was used to re-establish the blood flow in one case (false aneurysm), and an homologous arterial graft was used to bridge a defect and establish the blood flow in another case (arteriovenous fistula). In the remaining two the vessel continuity was re-established by suture anastomosis following excision of the fistula. Postoperatively, in these four patients peripheral pulses have remained good.

The importance and value of restoring blood flow in major vessels is emphasized by the following case.

A patient with a false aneurysm in the groin was first seen thirty days after injury; the dorsalis pedis and posterior tibial pulsations were strong. Twenty-eight days later the false aneurysm had enlarged and both dorsalis pedis and posterior tibial pulsations were absent. Operation was performed because of the extreme pallor of the foot and, we believe, impending gangrene. At operation the superficial femoral artery, which had been patent and functioning on admission, was apparently thrombosed. The aneurysm was in the common femoral artery at the origin of the profunda femoris. At operation, with all involved vessels temporarily occluded, the foot had a death-like pallor. Anastomosis was made between the common femoral and the profunda femoris artery, using the saphenous vein as an autogenous graft to bridge the defect. The color in the foot immediately improved. Sympathetic block gave good results and eight days later a lumbar sympathectomy was performed. This was the only sympathectomy performed in this group. The patient has a good, functioning leg with excellent pulses, but because of disabling wounds of the other knee, has been retired. Of the other three

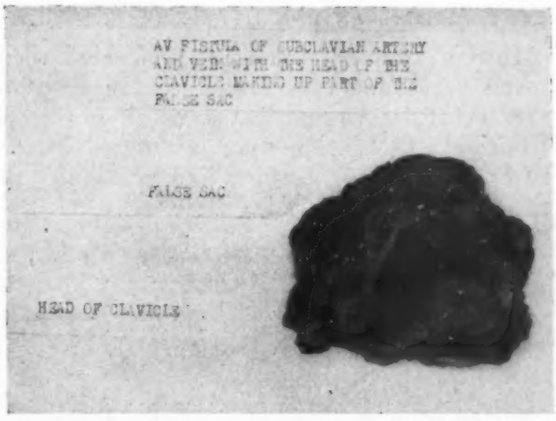


FIG. 11. A gunshot wound compounded the head of a clavicle. This posterior view of the resected clavicular head formed part of the false sac connected with a subclavian arteriovenous fistula.

cases, two have been placed on limited duty because of chronic venous insufficiency. Both of these patients had ligation of the common femoral vein at the time of operation.

SUPERFICIAL FEMORAL ARTERY (FIFTEEN CASES)

In this group two aneurysms and twelve arteriovenous fistulas of the fifteen cases have been operated upon at this writing. Continuity of the vessel was re-established in eight cases in this group. (Table v.) Six were operated upon by excision and ligation of the lesion. Two patients with excision and ligation developed symptoms and signs of chronic arterial insufficiency for which a sympathectomy was carried out one with good results and one with only fair results. Another had a sympathectomy for causalgia. Of the eight in which blood flow was re-established, none subsequently developed symptoms of arterial insufficiency, and pulsations distal to the site of injury have remained excellent in all. These eight patients have been or will be returned to duty.

TABLE V*

Excision and ligation	6
Artery repair by suture	5
Autogenous vein graft	3
Total	14

*Of the fifteen patients with superficial femoral false aneurysms and fistulas, fourteen have been operated upon with the vascular channel restored in eight cases.

POPLITEAL ARTERIES (TWENTY CASES)

In this group operation was performed upon seven false aneurysms and twelve arteriovenous fistulas. One patient is awaiting surgery. Excision and ligation were performed in ten cases. The remaining nine had continuity of the vessel re-established. (Table VI.)

TABLE VI*

Excision and ligation	10
Artery repair by suture	6
Autogenous vein graft	2
Homologous arterial graft	1
Total	19

* Nineteen patients with popliteal arteriovenous fistulas and false aneurysms have been operated upon as shown above.

Of these ten patients who had excision and ligation, chronic arterial insufficiency developed in five. Sympathectomy was performed with good results in four and poor results in one case. In the nine patients in whom blood flow to the extremity was re-established, three had disabling associated injuries but no arterial insufficiency. One of the remaining six had circulation re-established by repair of the torn artery wall. Following surgery the pulses were fair and have since decreased. This is considered at this time a failure to re-establish satisfactorily the vascular channel. However, of these six all have returned or are expected to return to duty.

COMMENTS

From the standpoint of technic in the operative care of vascular lesions, certain principles have been followed which may be of interest. In all cases wide exposure was carried out. When the line of incision crossed a joint surface, the incision was modified to minimize the scar across joint creases. Wherever the location of a lesion in the extremity permitted, a pneumatic tourniquet was applied proximally as a safeguard. Care was taken to avoid incision or a break into lesions until after tapes were passed around major vessels both above and below the lesion. In areas in which a tourniquet could not be applied, as in the subclavian area, exposure of vessels proximal to the lesions was carried out and tapes applied for the control of hemorrhage. This entailed thoracotomy in some cases with a view of controlling the subclavian, common carotid or innominate vessels. Portions of clavicle were sacrificed to the extent consistent with good exposure. Subperiosteal resection was performed with incision through the periosteal bed to reach vessels.

Neither heparin nor other anticoagulant agents were employed. In the majority of cases, aneurysmal sacs were left in place in order to preserve small collateral vessels which might course within the wall of the false sac. Such sacs were usually drained for a short period. As a rule, non-absorbable suture material was used thoroughout, except where frank infection was known to be present.

TABLE VII*

	No.	Percentage
Excision and ligation	29	45.3
Arterial repair by suture	23	35.9
Autogenous vein graft	7	10.9
Homologous arterial graft	5	7.9
Total	64	100

* Summarizes the type of operative procedure accomplished in the sixty-four cases in which there was injury to major arteries.

Initially in this study we used excision and ligation of aneurysms or fistulas as the method of choice for large arterial defects. Grafting of the vessels was reserved for those cases in which it was likely the extremity would be lost following ligation. The results in the latter group were so gratifying that we now attempt to restore the continuity of all major arteries. Accordingly it is our policy to reconstruct the arterial channel by either suture anastomosis or grafting, unless circumstances absolutely preclude such procedures. There was one failure and one poor result in the group in which reconstruction of the vessel continuity was undertaken. All except two patients have demonstrated good pulses distal to the anastomotic site, and many have follow-up angiograms which demonstrate the reconstructed vascular channel. All cases in which grafts have been employed are being carefully followed, and the results of the use of grafts in war wounded will be the subject of a later paper.

In contrasting results in the cases in which ligation and excision were performed in major vessels with those in which reconstructive procedures were accomplished, (Table VII)

it is of interest that 24.1 per cent of twenty-nine cases which were ligated developed arterial insufficiency while only 2.8 per cent of thirty-five cases which were reconstructed developed arterial insufficiency.

To subject these two groups to more careful study the large vessels of the head, neck and upper extremity have been placed in one group and those of the lower extremity in a second group for a comparison of surgical results. This is done because it is more difficult to evaluate accurately degrees of circulatory insufficiency in the upper extremity. Although many of our cases after ligation and excision showed a diminution in oscillometric and skin temperature readings, function of the arm and hand was adequate for usual activity, while in vascular lesions involving the large arterial trunks supplying the lower extremity, a definite and pronounced difference in the functional results was demonstrated. Of the thirty-six major vessel injuries in the lower extremity, sixteen patients had excision and ligation of the artery and twenty patients had the blood flow re-established by suture anastomosis or by means of grafting. Seven or 43.8 per cent of those ligated developed signs and symptoms of vascular insufficiency. Five of these had sympathectomy with good results but still do not compare in functional results with those cases in which the continuity of the vessel was re-established. In the twenty cases in which repair of the arterial channel was accomplished, only one has developed any evidence of arterial insufficiency. In this latter group, however, chronic venous insufficiency developed in two patients because of ligation of the common femoral vein.

SUMMARY

The management of 101 cases of traumatic battle-incurred arteriovenous fistulas and false aneurysms has been reported. Ninety patients were operated upon and in four cases the wound closed spontaneously. It is our policy to re-establish the continuity of all major vessels by suture anastomosis, homologous artery graft or autogenous vein graft. Of the sixty-four cases of lesions operated upon in major vessels, continuity was re-established by arterial repair and anastomosis in twenty-three, by autogenous vein grafts in seven and by homologous artery grafts in five. By these methods arterial continuity was re-established in 54.7 per cent of the major vessels operated upon with only one failure.

SURGICAL REPAIR OF INJURIES TO MAIN ARTERIES

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BONES, muscles and nerves are necessary for function of an extremity, but without blood vessels none of these will survive or function. When injury to the first three occurs, it is possible to delay repair and still regain function even after the loss of a considerable length of time. However, when the main blood vessels are damaged, it is a state of acute emergency in which the circulation must be restored within a matter of a few hours or all is lost. If the injury is such that it has not completely devitalized all tissue distally, it may still have impaired the circulation to such an extent that the nutrition of tissue is so reduced it is not able to combat infection, heat or cold, or other conditions which may exist. The relationship of gas gangrene and tetanus infection to devitalized tissue is well known.

In presenting the treatment and repair of injury to main vessels the following classification is useful: (1) contusion with damaged intima complicated by thrombosis; (2) incomplete division with hematoma and external hemorrhage; (3) complete division with hematoma and external hemorrhage; (4) loss of a segment of artery. With any of these injuries the accompanying vein may be damaged, thrombosed, divided or may have communication established with the arterial system.

The first essential under all conditions is to stop external hemorrhage and if possible limit the amount of hematoma if there is no external hemorrhage. Then follows a period of observation to determine if the peripheral circulation is adequate. If on general observations the circulation is good enough, the policy of waiting should be carried out because under these conditions, frequently with some treatment to assist the circulation, it may improve within a few hours. If not, the decisions must be reconsidered. If doubtful, wait and apply what may be done to assist the circulation in the way of sympathetic block, novocain intravenously, application of cold and dependency.[1] Again this must be watched for a limited time because if anything is to be done surgically it must be undertaken within a matter of a few hours, preferably within ten or twelve. If complete occlusion of the main vessels should have occurred, it is rarely possible because of extensive thrombosis in the vascular tree to accomplish much after eighteen to twenty-four hours. If the extremity with the following signs shows indisputable loss of circulation, something should be undertaken as soon as possible: The extremity will be cold, pulseless, insensitive and paralyzed, and white or blue in color. Always there is either a local hematoma suggesting a good deal of internal bleeding or an open wound through which the hematoma has escaped. If these conditions are present, there should be no delay and the area should be explored at the earliest possible moment.

At operation the incision should be made in the long axis of the vessel so that it can be extended as much as desired in either direction. The hematoma should be cleared, the main artery dissected and the perforation, if any, identified. If divided across, both ends must be dissected. At this time one must estimate whether a segment of the vessel is missing.

If the vessel is still open and bleeding, such as in a partial division or puncture, any clots in the lumen should be removed. Repair by everting, interrupted or continuous mattress sutures will close such a lateral incision quite satisfactorily if it is a cleanly incised wound. If it is not bleeding, both ends or the trunk if not completely divided must be cleared of clots and one must be certain of this. If after the immediate area of injury has been cleared there are still some doubts, saline or weak heparin solution may be injected some distance distal from the wound in both segments of the vessel, closing beyond with a light clip in each case so that the fluid will flush out through the open ends of the vessel. If the vessel has not been opened but is contused and not pulsating, an incision should be made transversely at the site of thrombosis and the point of greatest contusion, making a small opening into the lumen. If it is severely damaged and completely

occluded by clots, it should be divided completely across and then dealt with in a manner similar to that for a completely divided vessel. In some fairly distal main vessels it may not be necessary to undertake repair as collateral circulation may be adequate; and where there is a parallel main vessel, as in the forearm and leg, one or the other can be sacrificed with impunity by tying off both ends.

When this has been accomplished satisfactorily, both ends are trimmed back to healthy tissue where the intima, media and adventitia have fairly normal appearance. Now it is necessary to consider if, by suitably stretching the vessel and posturing the adjacent joints, an end-to-end suture can be carried out. This is preferable if it can be accomplished without too much tension. If, however, the ends do not come together satisfactorily or the stretch is too great, it is preferable to apply a graft. Rarely under these emergency conditions will an arterial graft be available; but if one is, it may be used. On the other hand, it has been demonstrated by the author both experimentally and clinically[2] that venous grafts can be applied with satisfactory results. If the latter is decided upon, the adjacent or other suitable vein may be used, placing the graft so that the valves lie open in the arterial current. Although many methods have been used for closing such a suture line, sewing with fine silk is preferable to the various clips such as Payr's, Blakemore and Lord's tubes, etc.

If lateral repair, end-to-end suture or graft, either arterial or venous, has been applied, it is advisable to heparinize this area to protect the suture lines and graft against thrombosis and to be more certain of a good end result. This may be accomplished by general heparinization of the patient (heparin is better than any of the other anticoagulants for this particular purpose) or by regional heparinization as described in an earlier paper by the author.[3] At that time we used steel or gold needles placed in the lumen of the vessel proximal to the site of repair, with the needle pointing upstream so that the heparin flowing from the needle would pass over the site of the needle puncture in the artery and then over the sutured areas. At the present time with very fine polythene tubing this can be placed in a similar fashion with less difficulty in keeping it in position and less problem when it is removed. If regional heparinization is to be used, one is immediately confronted with the problem of injecting the solution against arterial blood pressure. This is difficult to do at an appropriate rate with gravity alone and requires a good pump to be sure to deliver the right amount of heparin against such pressure. This method has a great advantage in not affecting the patient generally and it requires an infinitismal amount of heparin compared with that required for heparinization of the patient as a whole.

From our experience experimentally[4] it was determined that an end-to-end suture line is healed and endothelialized in seventy-two hours and on that basis we have decided clinically to heparinize such repairs for seventy-two hours or slightly longer. If, however, a graft is used, it requires heparinization for not less than eight days and to be on the safe side we have continued for ten, twelve to fourteen days for safety under these conditions.

The fate of a venous graft has been under considerable discussion but it was demonstrated by the author[5] that a venous graft is viable with a bleeding surface with healthy intima and viable media on section. Moreover, I have recently recovered a venous graft which had functioned in the carotid artery of a dog for nine years. Figure 1 shows the graft slightly larger than the adjacent artery. There is some arteriosclerotic change at one point in the vessel and on section there is a small amount of bone formed at this area. Otherwise the graft was functioning naturally, was patent and had worked satisfactorily for that period.

In a fair number of patients end-to-end sutures of arteries have been carried out which were eminently satisfactory, with normal restoration of circulation. There were four patients with venous grafts in the main femoral arteries of more than fourteen years' duration. One of these in particular was a graft of femoral vein 2½ inches in length applied in the main femoral artery just below Poupart's ligament. It was in such a position in Scarpa's triangle where it could be kept under close observation. The individual had a lacerated wound completely dividing across the femoral artery including the vein, all of which had been tied off by an excellent surgeon who saved the patient's life. Within a matter of hours, however, circulation to the extremity was inadequate and it was decided to do something further in the way of repair. The author trimmed up the field and applied a 2½ inch graft of adjacent femoral

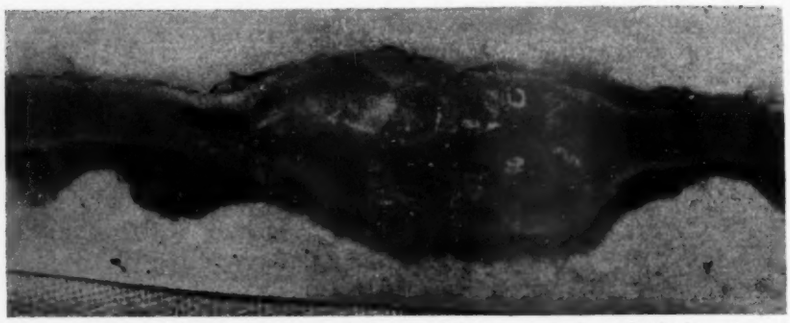
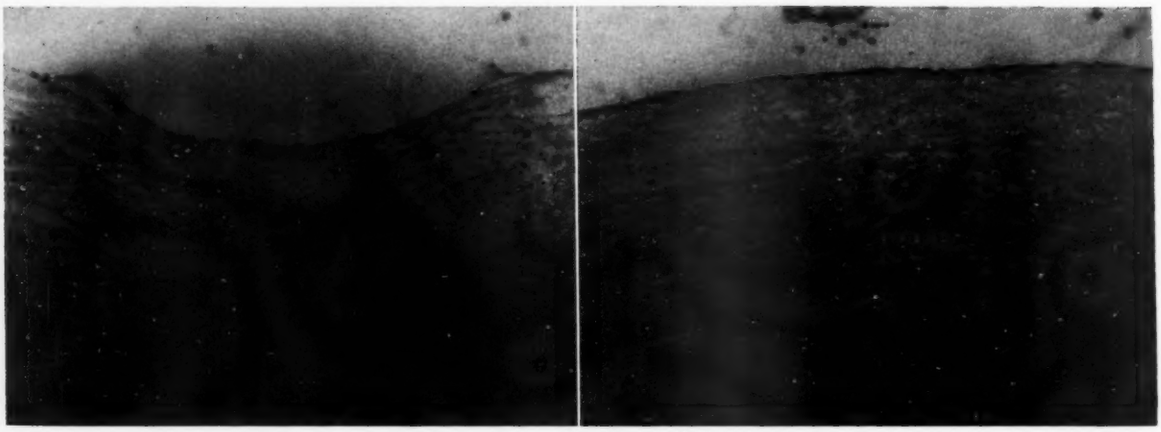


FIG. 1. External jugular vein graft in carotid artery of dog which functioned for nine years. The graft is patent, is slightly larger than the adjacent artery at each end and shows some atherosclerosis.



2 3

FIG. 2. Patient's aorta adjacent to graft; hematoxylin and eosin.
FIG. 3. Homogenous graft of aorta which functioned as a portion of patient's aorta for four months; hematoxylin and eosin.

vein in the common femoral artery. This has functioned *in situ* now for fifteen years. There is no dilation, no aneurysm formation, no degeneration or calcification that can be felt and no demonstrable narrowing, and the arteriogram shows quite a normal vessel at this level. Several others have been done, of shorter duration, and are functioning satisfactorily. There is no question of the advisability of repair of main vessels which is of the greatest importance in saving extremities under certain conditions.

Regarding the further use of grafts, three abdominal aneurysms have been resected and aortic grafts applied, as advocated by Gross. The longest of these was 7 inches, the next 5½ and the third 4 inches in length, all of which functioned satisfactorily. One patient died after four months from a cerebrovascular accident and the specimen was recovered. The graft was functioning satisfactorily, was viable with no sign of giving way and was satisfactory in all respects. (Figs. 2 and 3.)

If venous communication has been established which is causing impairment of circulation or cardiac damage, it should be dealt with in a similar fashion. Resection alone with quadruple ligation will give excellent results here, but restoration of the circulation is preferable if possible.

CONCLUSIONS

If there is evidence of injury to a main artery of an extremity or head and neck with evidence of severe or completely impaired circulation, the area should be explored at the earliest possible moment, preferably within twelve hours. Depending upon the conditions found, it may be possible to do (1) ligation of the vessels, (2) an end-to-end suture, (3) apply a venous or arterial graft with excellent prospects of returning the circulation to normal.

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ROUND TABLE DISCUSSION ON VASCULAR PROBLEMS

CHAIRMAN LOUIS G. HERRMANN: The immediate seriousness of wounds of violence depends to a great degree upon the extent and kind of injury to the underlying large blood vessels. Methods of controlling hemorrhage from wounds of large blood vessels have excited great interest among surgeons from the very earliest times, not only because excessive loss of blood is always the most serious immediate consequence of such an injury but also because an ample supply of arterial blood to the parts beyond the point of injury must be maintained or serious complications are certain to follow.

Often associated with these injuries is severe shock resulting from diminution in the blood volume with a precipitous fall of blood pressure. When injuries are very extensive, the primary objective of therapy should be to get the patient in the best possible general condition since any premature attempt to repair the vascular damage or to save the limb might easily result in the death of the patient.

Dr. Hamilton and his associates have been interested in the effects of severe hemorrhage upon traumatized patients, and their wide experience with restoration of blood volume in seriously injured patients has been presented by Dr. Drye.

It is not always possible by clinical studies alone to determine the extent of intracranial bleeding. Drs. Webster and Gurdjian, who have told us of their experiences, have employed angiography in the evaluation of massive intracranial hemorrhage.

In most wounds of violence which affect the extremities there is also considerable damage to the surrounding tissues, especially the nerves and frequently the bones. Localized vasospasm of a high degree may result from injuries to the large arteries or large nerves. In World War I French surgeons called this phenomenon "stupor arterielle." Often prolonged spasm of arteries and arterioles lead to aseptic necrosis of muscles of extremities or widespread venous and arterial thrombosis with resulting contractions of the Volkmann type.

The accumulation of blood beneath the deep fascia of such an extremity may further occlude by compression all available collateral arterial pathways. Traumatic vasospasm is still one of the dreaded complications of crushing injuries to extremities, so it is fitting that we have heard from Dr. Gardner who has had some interesting experiences with this type of vasospasm and its complications.

The great increase in the number of injuries to large blood vessels which have resulted from military operations has given General Seeley and his associates an opportunity which they have used to real advantage. Most of us believe that re-establishment of the continuity of large arteries is to be desired when great arteries are severed or severely traumatized even if this restoration of the flow of blood through the artery remains active for only a few days. Valuable time for the development of collateral arterial circulation is thereby gained. General Seeley and his group at the Walter Reed Army Hospital in Washington have shown that a great number of successful restitutions of the arterial circulation are possible with the improvement in the technics of vascular surgery.

General Seeley has been able to convince his superiors that the Walter Reed Army Hospital should continue to be the center of vascular surgery for this country. The outstanding work which was accomplished there during World War II under the direction of Colonel Elkin will forever stand as one of the important milestones along the rocky road of vascular surgery.

With newer methods and wider experience there has continued to be a reduction of complications and a lessening of the period of disability even in patients with extensive injuries to great blood vessels. General Seeley and his staff have contributed greatly to this advance in vascular surgery. It is indeed a pleasure and a privilege to have General Seeley and Colonel Hughes tell us of the work they have been doing for the men who were brought back from the battle fronts in Korea.

GENERAL SAM F. SEELEY: Thank you very much, Dr. Herrmann. I happened to be the executive officer at The Greenbrier at White Sulphur Springs, Virginia, at the time that the

Army was procuring that installation to make it into a large general hospital. When we learned that Dr. Daniel Elkin was coming to us as chief of surgery, we immediately recommended to the War Department that The Greenbrier be made a vascular surgical center. This recommendation was accepted and approved.

As a result so many vascular cases were received at The Greenbrier that later two other centers were opened. Dr. Schumaker manned one of these, and his studies and contributions are well known. Dr. Elkin has treated more patients than any other single living surgeon or anyone who has placed reports into the literature, having over 450 cases of arteriovenous fistula and aneurysm during those years at Greenbriar.

Early in July, 1950, a patient with arteriovenous fistula arrived at Walter Reed from Korea. We recommended then to the Surgeon General that a center for vascular surgery be set up at Walter Reed Army Hospital. Again, this recommendation was approved. We were able to get Dr. Elkin to come up and spend two days a month lecturing and demonstrating surgical approaches and management. Over 90 per cent of 109 patients who have arrived to date, with 118 lesions, have been operated upon, and 90 per cent of those operations have been performed by our senior residents at the hospital under Dr. Elkin's guidance.

CHAIRMAN HERRMANN: Such an opportunity in vascular surgery has never before been given to any one group of surgeons. Their work has been well done and their results are superior to any which have previously been reported. We hope they will continue to push forward these boundaries of technical surgery of the vascular system.

We should now pay tribute to one who laid down some of the important fundamental principles for the surgical restoration of the continuity of large blood vessels more than twenty years ago. This man successfully bridged gaps in arteries by suturing into the gap a segment of a peripheral vein. He also has many good ideas about the repair of injuries to large blood vessels. He is, of course, Dr. Gordon Murray of Toronto.

It is my unpleasant duty to put our experts to test to defend their ideas and procedures and to add further to this interesting Symposium on Surgery of the Peripheral Vascular System. Let us proceed, then, to the question and answer part of our program.

Holman and others have advocated a long waiting period before operating upon arteriovenous fistula in order to allow for the development of adequate collateral circulation. Recent articles seem to show that most of the collateral is venous. How is the operating time determined? I should like to have General Seeley answer this question for us.

GENERAL SEELEY: Initially, we did not know how long to wait before we operated upon an arteriovenous fistula. Dr. Elkin suggested a minimum of three months, which has been the average; we have not deviated from this except when an enlarging aneurysm, either in conjunction with an arteriovenous fistula or an aneurysm *per se*, might force our hand. In Japan the usual time of the "blowout" in arterial aneurysm has been between the twelfth and seventeenth days, under which circumstances they then have had to undertake emergency procedures.

We believe that with development of technics of either vein or arterial grafts it might be perfectly feasible to shorten the three months' waiting period. However, our experience to this moment is insufficient to justify a blanket change in policy.

CHAIRMAN HERRMANN: We have been asked about the use of heparin after arterial grafts and transplantations of veins or arteries. We should like Dr. Murray to say a few words first and then General Seeley will add his comments.

DR. GORDON MURRAY: I do not presume to differ with the great authority across the border in the United States. We have done experimental work on heparin which influences me to think that with this we can be sure of better results. In the larger vessels, in arterial end-to-end suture, I think perhaps you can get by very well without it. However, in our experience the results are more positive; we can be more certain of the area remaining patent by using an anticoagulant.

Regional heparinization has the advantage that it takes very little of the drug, which is relatively expensive (that does not apply in the army, I suppose), but the difficulty with it is that you must have a fairly good system to inject this heparin against arterial blood pressure. If you are going to use gravity, you must have a high ceiling with rafters way up to get the heparin high enough to push it in

with gravity. If not you must have a good pump because you will probably be giving a small quantity and it is not easy to know if the pump is delivering what is needed.

Doing clotting times in the patient as a whole will not help you in the least so you must determine beforehand how much you are going to give and at what rate.

In my own experience, in all of Blalock's operations, Potts' and the others, I give heparin. Probably that is my weakness. A lot of people do not. However, it does probably eliminate some of the complications in those people such as, say, thrombosis at the suture line and the tendency to cerebral thrombosis which occurs in that group of congenital hearts.

CHAIRMAN HERRMANN: Another question which many members have asked concerns the operation of lumbar sympathectomy as a necessary procedure prior to quadruple ligation and resection of arteriovenous aneurysms. General Seeley, would you be kind enough to answer that question?

GENERAL SEELEY: We have operated in some ninety-four cases and in only one, a congenital arteriovenous fistula operated upon before the Korean affair, did the patient receive heparin. We have no cause to regret omission of its use. It may be that meticulous surgical technic in the apposition of intima (we employ a continuous everted mattress suture) obviates the need for anticoagulant drugs.

We reserve sympathectomy for that case which shows arterial insufficiency. We grant that some minor degrees of arterial insufficiency may take many weeks or months to develop in the form of glossy skin or coldness of the extremities upon exposure to cold air and we will not overlook the necessity for sympathectomy should it be indicated at a later date.

CHAIRMAN HERRMANN: There have been several questions concerning the use of the Blakemore-Lord tubes and cuffs for the non-suture anastomosis of large arteries. I should like very much to call upon Dr. Lord to answer this question.

DR. JERE W. LORD, JR.: Dr. Herrmann, I do this at the prodding of my good friend, Dr. Patterson, back there who thought it wise for me to try to clarify a point. Dr. Blakemore and I, in a year of study of some 100 animals in 1942, found the vitallium tube vein graft method worked a good deal better than the suture method using a vein graft in which one used the over and over suture technic. At that time we did not use the current and proper method of an everting mattress suture which General Seeley has mentioned.

We did not give up the vitallium tube vein graft method because it thrombosed regularly. It worked in about 90 per cent of all dogs in which we used the small femoral artery, which Dr. Murray pointed out requires heparin in his experience. The reason it was abandoned was simply that it takes as much experience to learn to use it as it does to use a suture method of the everting mattress type. Therefore, since it is no better than that, and we believe no worse, we think it is much better for the surgeon to learn one good technic. Secondly, it is not useful for end-to-side anastomosis unless the vessel is very large, whereas the suture method is ideal for that purpose.

The proof that it functions well is the work of Sweet and Bland in using the most difficult of all anastomoses, and that is vein-to-vein. They found it worked better than using a suture method when they did the Bland-Sweet operation for mitral stenosis, joining the azygos vein to the dorsal segment branch of the inferior pulmonary vein. We can say, then, that the method has been abandoned except in two places: first, the Bland-Sweet operation which may itself be abandoned some day, and secondly, as Dr. Blakemore pointed out, in the inlay vein graft method of maintaining arterial continuity in aneurysms without injury to the collateral circulation. In that site it still has usefulness and I think probably always will.

CHAIRMAN HERRMANN: Several of our members have asked questions concerning the peripheral vasospasm about which Dr. Gardner talked to us. The first question is: Would you consider the use of intravenous novocain or tetraethylammonium chloride in traumatic vasospasm? I should like to call upon Dr. Gardner to discuss this.

DR. CAMPBELL GARDNER: I am afraid I cannot answer those questions.

CHAIRMAN HERRMANN: We have two questions which deal with the repair of the major vein when the artery is reconstructed in the cure of an arteriovenous aneurysm. I wonder whether General Seeley would comment about the dangers connected with the repair or reconstruction of large peripheral veins.

GENERAL SEELEY: In cases of lesions of a small vessel such as the radial artery we have

done repair with an end-to-end anastomosis whenever possible. We apply this same principle to the vein wherever possible. We prefer not to sacrifice the fellow vein, particularly in the femoral area. In three cases in which the femoral vein was sacrificed venous congestion and swelling ensued.

CHAIRMAN HERRMANN: Doctor Gardner has brought up several very important questions in the presentation of his paper but I doubt if the problem is quite as hopeless as he has indicated. It is important to use all methods of overcoming peripheral vasospasm as soon as the condition is recognized in order to prevent the more serious consequences of prolonged ischemia of the muscles in an extremity. It has been our experience that early novocainization of the regional sympathetic ganglia in such patients frequently gives rise to prolonged peripheral vasodilatation and prevents the appearance of the more serious complications. Doctor Murray has had considerable experience with peripheral vasospasm and I wonder if he would be kind enough to discuss this problem for us.

DR. MURRAY: There are several things that impress me in Dr. Gardner's presentation. I know Dr. Gardner and he knows me, and what I am saying is, after a fashion, pulling his leg; as the French would say, "teni le jambe."

One of his patients had convulsions, another one had eye signs indicating cerebral effect and a third one had spasm of an artery in an arm, quite remote from the site of the original injury. I am just wondering about this. I do not know a thing about it but my suggestion would be that this is not spasm of the vessel at all.

I will tell you of a situation. A young woman who had had a minor injury was brought to me. Tetanus had developed and the doctors in all good faith had started treating her energetically with tetanus antiserum intravenously. The young woman died but before she did, about the end of seven or eight days, gangrene of a patch of skin on the front of both tibial regions developed; that is, the extensor group of muscles on each leg began to slough. Gangrene of the toes and gangrene of a patch of skin on the abdominal wall also developed. The patient was unconscious. She had convulsions and anuria. I am still wondering what the cause was.

Another woman had fat embolism. She had a simple fracture without complications, yet all of these vasomotor manifestations developed. I would like to know if Dr. Gardner's patients had been investigated for fat embolism. To my mind that is a more common complication of injury than is generally recognized and it can produce many of these signs about which we are talking.

CHAIRMAN HERRMANN: It has been a real pleasure to present these experts and to have the opportunity of guiding their discussion of these important problems. All surgeons who deal with wounds of violence must constantly bear in mind the importance of injuries to the great blood vessels and insist that definitive treatment of such injuries be carried out with the shortest possible delay.

I appreciate the privilege of acting as moderator for this important symposium.

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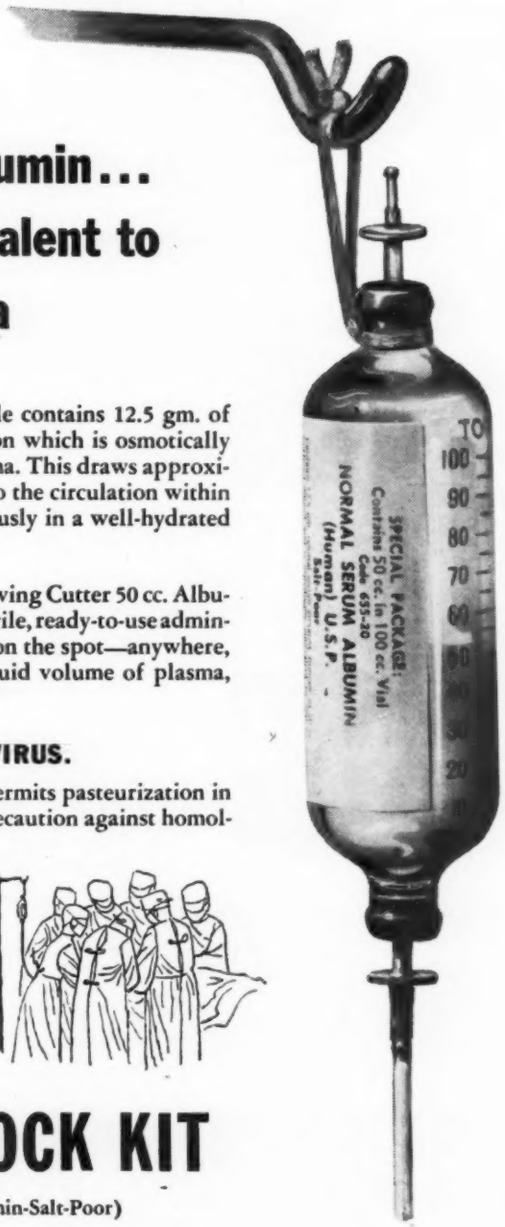

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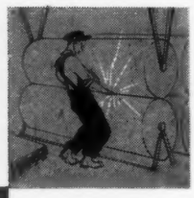

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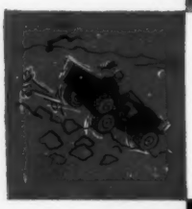

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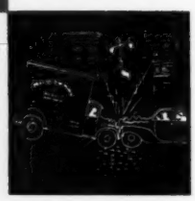

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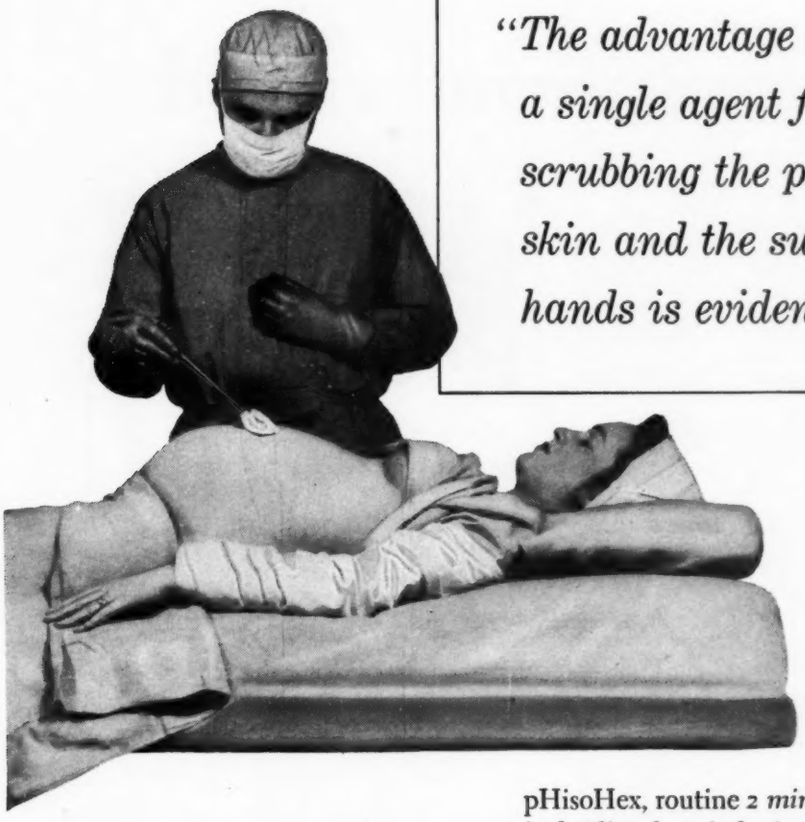

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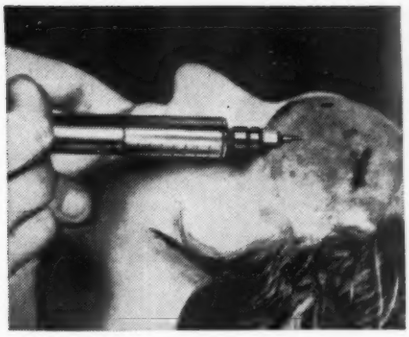

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CASE HISTORIES...

CASE 43

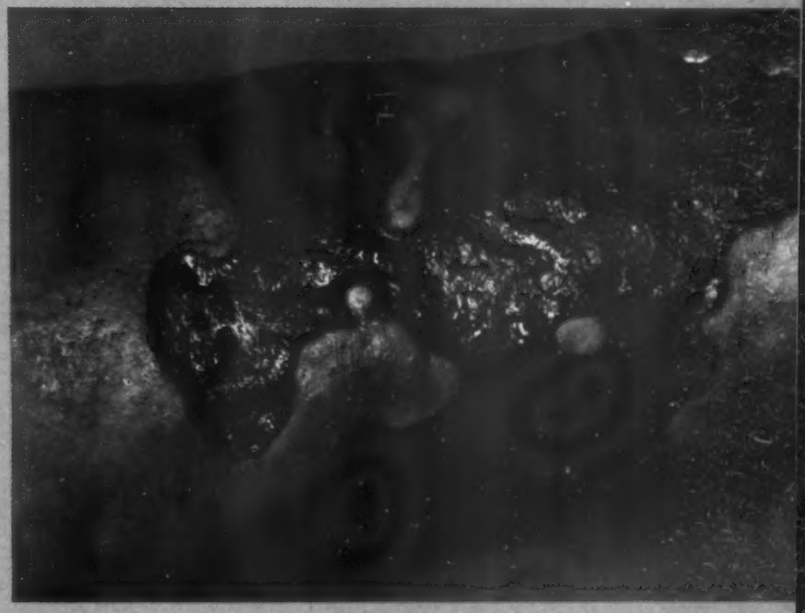
J.K. Chronic Undermining Ulcer 26 Years' Duration

Prior to institution of Tryptar and after 26 years of unsuccessful therapy.

Patient sustained a hot-water burn on left leg in 1920, at age 15. Five years later, following a slight trauma to this area, an ulcer developed which became progressively larger and deeper over a period of 26 years . . . despite all established medical therapy, such as ointments (radon, sulfonamide, penicillin, chloresium, allantoin, furacin, zinc oxide), irradiation and skin grafting. Photograph (left) shows ulcer covered by tenacious, greenish-yellow, offensive smelling exudate.

In 1951, 2 vials of 250,000 Armour Units of Tryptar powder was applied by powder blower following rinsing of ulcer with Tryptar Diluent (Sorensen's Phosphate Buffer Solution). After 30 minutes, the Tryptar powder was washed off and approximately 90 per cent of the necrotic tissue had disappeared. Six hours later, Tryptar powder was again applied and the same procedure was repeated once on the following day. Twenty-four hours after first application of Tryptar the ulcer was practically clean and odorless. Photograph at this time (right) shows new granulation tissue throughout the lesion.

*THE ARMOUR LABORATORIES BRAND OF PURIFIED CRYSTALLINE TRYPSIN



Twenty-four hours after institution of Tryptar.

Tryptar

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WHAT IT'S FOR: . . . . . Suppurating and necrotic lesions and infected wounds, such as Varicose Ulcers, Decubitus Ulcers, Diabetic or Arteriosclerotic Gangrene, and Open Infected Wounds. Tryptar is also indicated in many other conditions. (Complete list of indications supplied on request.)

WHAT IT DOES: . . . . . Causes dissolution of necrotic tissue and removes debris without adversely affecting living tissue.

HOW TO APPLY: . . . . . ***If the lesion is moist:*** Irrigate lesion with Tryptar Diluent (Sorensen's Phosphate Buffer Solution) to adjust the surface pH for optimal efficacy; then apply Tryptar powder by use of powder blower or by sprinkling from the original vial.

(IN SURFACE ULCERS)

If the lesion is dry: Prepare Tryptar solution by adding 25 cc. of Tryptar Diluent to the vial containing Tryptar powder (250,000 Armour Units); moisten sterile gauze sponges thoroughly and cover area to be treated.

REFERENCES

(1) Reiser, H. G., Patton, R., and Roettig, L. C.: Arch. Surg. 63: 568-575, 1951; (2) Reiser, H. G., Roettig, L. C., and Curtis, G. M.: Tryptar Debridement of Fibrinopurulent Empyema. Philadelphia, W. B. Saunders Co., 1950; (3) Reiser, H. G.: Personal Communication.

SUPPLIED: Tryptar is supplied as a two-vial preparation: One 30 cc. vial contains 250,000 Armour Units (250 mg. of tryptic activity) of highly purified crystalline trypsin; the companion 30 cc. vial contains 25 cc. of Tryptar Diluent (Sorensen's Phosphate Buffer Solution) pH 7.1; plus plastic adapter for use with powder blower.

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1. De Lee Greenhill, Principles and Practices of Obstetrics, 8th Ed., p. 803, W. B. Saunders, 1943

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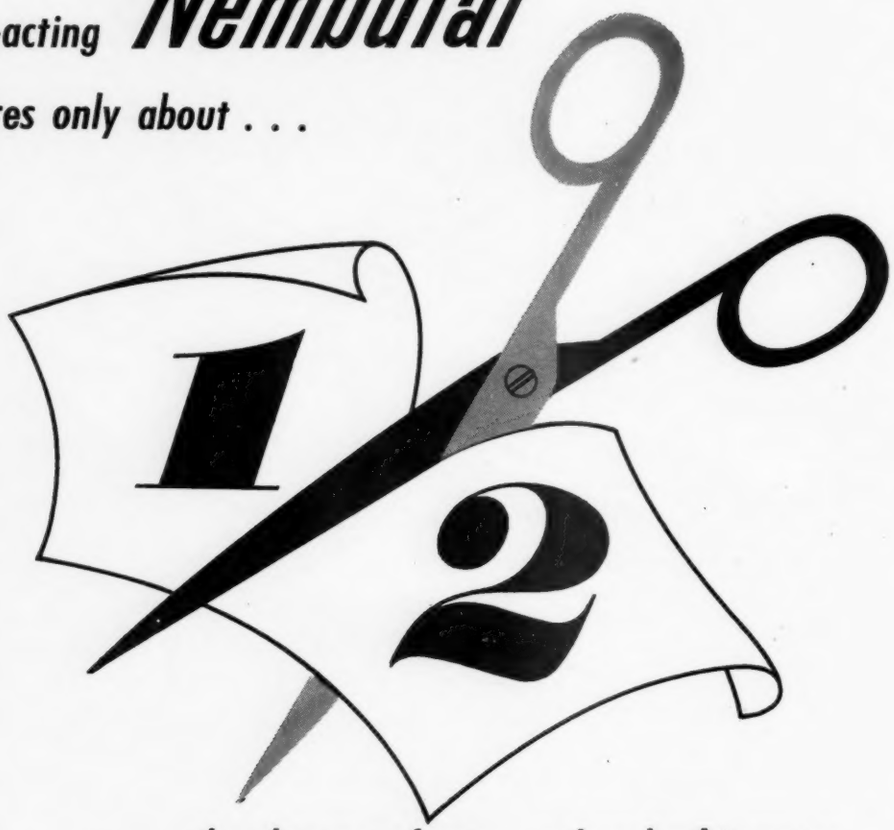

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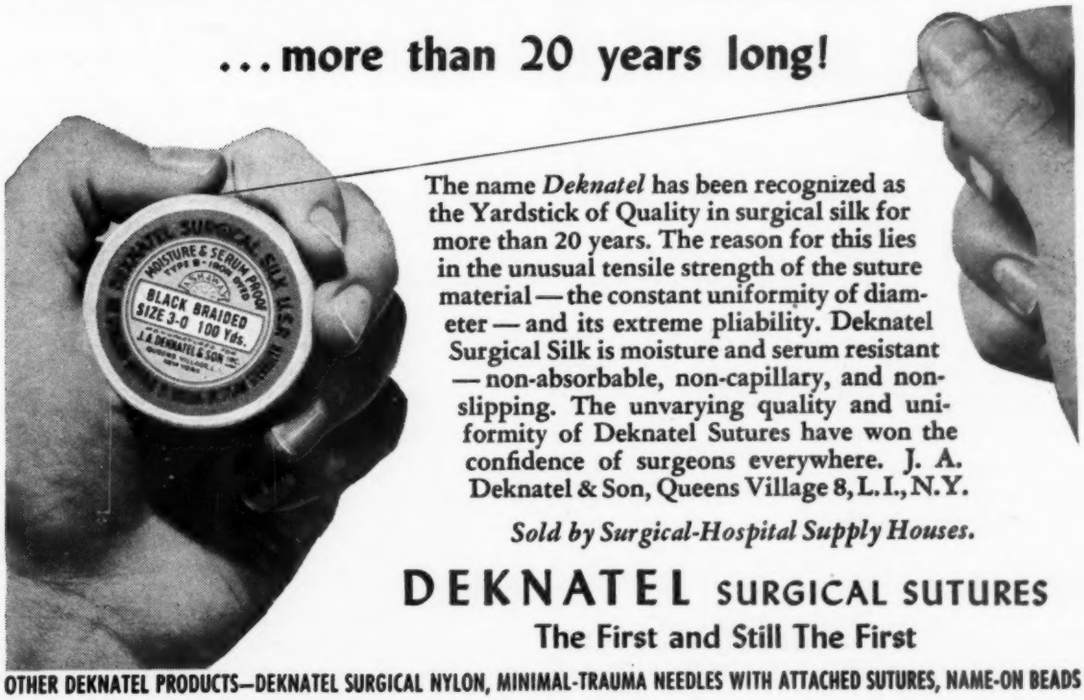

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Outside the Ivory Tower

DR. Leonard A. Scheele, Surgeon General of the Public Health Service, Federal Security Agency, recently said that many patients with tuberculosis are receiving inadequate hospital care because of a serious shortage of nurses in the Nation's tuberculosis hospitals and services. The situation is extremely acute and there are approximately 320,000 civilian nurses employed in all types of services today, but there is room for 65,000 more. The problem in tuberculosis hospitals is due in part to the nationwide shortage of nurses, which has resulted in stiff competition for their services, but it is due also to unfavorable working conditions in many tuberculosis hospitals. He mentioned that in many cases inadequate patient care can be traced to inferior hospital facilities, unsatisfactory personnel policies, and insufficient personnel and patient education. There is only one professional nurse for each 10.6 tuberculosis patients, whereas in general hospitals there is one professional nurse for each 2.5 patients. Now that treatment for the disease includes not only rest but also extensive chemotherapy and surgery, almost as many nurses are needed in tuberculosis as in general hospitals.

VITAL statistics now available reveal that deaths from heart disease and cancer among children of school age exceed in number deaths from all infections and parasitic diseases combined, it was announced by the Federal Security Agency. The announcement is based on a study by the National Heart Institute of the National Institutes of Health, Public Health Service, of population mortality figures compiled by the National Office of Vital Statistics. In 1948, the latest year for which complete figures are available, the study revealed cardiovascular disease and cancer deaths, with rheumatic heart disease and leukemia the leading causes, totaled 4,514 in the five to nineteen age group. In comparison, the infectious and parasitic diseases, with tuberculosis the chief cause of death, accounted for 3,990 deaths in the same age group.

THE possibility of discovering cancer of the uterine cervix and starting treatment five to seven years before the typical symptoms appear has been demonstrated in clinical studies made by the Public Health Service. In examining a group of more than 3,000 women at a clinic formerly operated by the Cancer Control Branch of the National Cancer Institute at Hot Springs, Arkansas, two physicians assembled data which suggested that the majority of cervical malignancies existing in a group of female patients are present in an asymptomatic, localized form for a minimum of five to seven years before the typical symptoms and clinical appearance of cancer become apparent. The studies were made by Dr. Rodney B. Nelson, formerly Senior Assistant Surgeon (R), and Dr. Albert W. Hilberg, Surgeon (R) of the Public Health Service. In their examinations the two doctors employed the cytologic test and the biopsy. The former is the taking of a "smear" from the surface of the cervix while the latter is the taking of a small specimen of tissue. Results of both these tests are disclosed in laboratory examination of the material to determine whether cancer cells are present. The cytologic test is made first and usually indicates whether a biopsy should be made. "Under the conditions of this study," Drs. Nelson and Hilberg reported, "the combined accuracy of the two techniques in diagnosing carcinoma of the cervix approaches 100 per cent."

THE manpower crisis of 1951 may prove to be the turning point which will compel industry at large to recognize the importance of doing something about the problem drinker. This observation was made at the annual meeting of the American Sociological Society by Robert Straus, Research Associate in Applied Physiology in the Yale University Center of Alcohol Studies. Straus, discussing problem drinking in industry during periods of manpower shortage, said: "When plants are short handed and the pressure for production is great, there is bound to be an increase in the tension and responsibility under which individuals work. Since alcohol is frequently used by the problem drinker in order to obtain pseudo-relief from feelings of tension and anxiety, increasing pressure may well contribute to an increase in drinking. Furthermore, in times of manpower shortage, industry is forced to employ so-called marginal workers including drifters, homeless and other socially unstable individuals. Available studies indicate

(*continued on page 46*)

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For best results use Onkosponge No. 1 and Gladstone Sponge Biopsy Forceps, prepared and designed especially for Sponge Biopsy.

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* Ref. Am. J. Surg., March, 1951.
J.A.M.A. April 21, 1951 p. 1238

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They fit all Beaver knife handles.

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Outside the Ivory Tower

(*continued from page 44*)

that these groups are heavily weighted with problem drinkers and alcoholics. With a remarkable transition in society's response to alcoholism well under way, the indentification of alcoholism as an industrial problem well established, and with several prominent industrial concerns setting a precedent, the manpower crisis of 1951 may well prove to be a turning point with respect to a general recognition of the problem drinker on the part of industry at large."

DR. Willard C. Rappleye, dean of Columbia University's Faculty of Medicine, called for training which would enlarge the scope of the physician's services to society and announced Columbia's plans for setting up an Institute of Administrative Medicine in which such training will be offered for the first time. The Institute program will begin operating about January 1, 1952. The plan is regarded as one of the most important developments in the College of Physicians and Surgeons since the establishment of the Columbia-Presbyterian Medical Center in 1928. The new Institute, which has been organized within the framework of the School of Public Health, will combine a program of training graduate medical students for administrative leadership with an extensive research program designed to determine the best methods for delivering maximum medical care to the American people at reasonable cost. It will offer, for the first time in any institution, an advanced degree in Administrative Medicine. In Dr. Rappleye's opinion the end result of this kind of training program will be to return the administration of health to the hands of specially trained members of the medical profession. Dr. Rappleye said that he further believed that, because of its economic and social aspects and the vital role the Institute will play in giving the nation better medical care, medical administration "may well become one of the most important branches of medicine."

The program of the Institute will be divided among five major fields of activity, as follows: (1) hospital administration, (2) prepayment medical care, (3) public health administration, (4) industrial medical administration and (5) medical school administration.

ACCIDENT fatalities in the United States increased markedly in 1951, reversing the downward trend of the preceding three years, Metropolitan Life Insurance Company statisticians report. It is estimated that approximately 95,000 lives were lost in accidents this year, about 5,000 more than in 1950.

Each of the main classes of mishaps, except home accidents, accounted for more deaths in 1951 than in the year before. Motor vehicle fatalities increased by approximately 2,500, reaching a total of 37,500, the highest annual toll in a decade.

A NEW apparatus in the field of orthopedic therapy was recently reported in a paper read before a joint Baltimore-Philadelphia Orthopedic Group meeting at the College of Physicians by Dr. Bernard D. Judovich.

Dr. Judovich, known for his work in pain problems and co-author of the book "Pain Syndromes," has perfected an intermittent traction apparatus for the treatment of patients suffering from herniated cervical and lumbar discs and other conditions in which traction is of benefit. This electrically controlled machine has remarkably improved and facilitated the use of traction therapy.

CONTRARY to the tradition of death and disease as an aftermath of great wars, mortality among the wage-earner population of the United States has improved materially since the end of World War II. During the five years since the conflict ended the death rate has dropped by one-eighth. This is based upon the experience among the industrial policyholders of the Metropolitan Life Insurance Company, as reported by Dr. Louis I. Dublin, second vice-president and statistician. Among the millions of policyholders the adjusted death rate declined from 529.2 per 100,000 in 1946 to 463.2 in 1950, and the average length of life has increased by practically three years, reaching 68.3 years in 1950.

"The recent spectacular improvement in mortality and gain in average length of life for the insured group is a continuation of the favorable trend of the past thirty-five years," Dr. Dublin commented. "Both sexes have benefited, although the trend has been more favorable for females than for males."

(*continued on page 48*)

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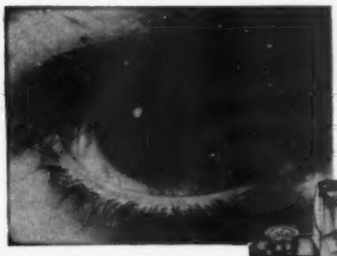

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COSMEVO 216 Paterson St., Paterson, N. J.

Outside the Ivory Tower

(*continued from page 46*)

WILLIAMS & WILKINS have brought out the fifth edition of Dr. Alfred C. Beck's Obstetrical Practice, which has been called the best textbook on this subject published. It is the preferred text in over 70 per cent of the medical schools in this country.

The first edition was published in 1935, the second in 1939, the first Portuguese edition in 1940, the third edition in 1942 and a Spanish edition in 1947. It was reprinted in 1948 and 1950 and now in 1952 the fifth edition is in circulation.

The work has been practically rewritten. In the author's Preface he enumerates the many advancements that have been made in the obstetrical field and relates the additions necessary to the text. Some chapters are new and other chapters were rewritten in part or *in toto*. In addition this book contains 106 new illustrations and an appendix of 22 reproductions of x-ray films. (Due to a method of reproduction devised by the author, we do not hesitate to say they are the finest reproductions we have ever seen.) We are told that because many of the old cuts had become badly worn, 390 of the illustrations have also been redrawn.

Although the work is 1,073 pages long the writing is to the point; there is no verbose padding, and one instantly discerns behind the written word a teacher of long experience and a scientist with a broad and accurate knowledge of all the phases of his subject. Those who have known and have had contact with him acknowledge Dr. Beck as one teacher in a thousand and his text reflects this rare ability in every paragraph. Space does not permit us to go into the details of this work. At the chapter endings are references, in some instances these cover several pages and there is an ample index.

For students, hospital housemen and those in our profession who limit their work to obstetrics this work should be a must and should be read and reread as an obstetrical text; it is truly outstanding. *Price:* $10.

Another worth while work, especially to those interested in radiology, is An Atlas of Normal Radiographic Anatomy by Isadore Meschan, M.D., with the assistance of R. M. F. Farrer, M.B., B.S. (Melbourne, Australia). We understand the work was undertaken to fulfill some of the needs of teachers of morbid anatomy, of radiology, of clinical medicine, and general practitioners who had need for a ready guide and reference in their everyday problems, and for more intelligent consultation with the specialist in radiology. This work of 593 pages has 1,044 illustrations on 362 figures. The text is clear and all in all will prove of great value to many physicians. It is published by the W. B. Saunders Company. *Price:* $15.

W. B. Saunders Company have published Surgical Practice of the Lahey Clinic by Members of the Staff of The Lahey Clinic, Boston. There are seventy-nine articles dealing with The Thyroid Gland and Neck, Esophagus, Lungs and Heart, Stomach and Duodenum, Small Intestine, Colon, Sigmoid and Rectum, Biliary Tract, Spleen, Adrenal Gland and Pancreas, Breast, Pelvis, Bones and Joints, Brain, Spinal Cord and Nerves, and Anesthesia. All writing is of a high scientific order. The book is 1,014 pages long, has 784 illustrations on 509 figures, references at chapter endings and an ample index. It is highly recommended. $15.

THE new University of Wisconsin Easter Seal Cerebral Palsy center opened January 2nd. The center will be supported by a $45,000 grant from the Wisconsin Association for the Disabled. The grant was accepted by the University of Wisconsin regents in September and provides $15,000 a year for three years to support the center, which will be located in the orthopedic hospital on the university's medical campus.

"The function of the center will be to coordinate and augment our previous services to cerebral palsy patients," says Dr. Mabel G. Masten, chairman of the center's sixteen-member advisory committee. "We now will be able to add occupational, physical, and speech therapists, and a social worker to our service."

The center is aiming at a coordinated program of examination, evaluation, treatment, occupational and physical therapy, and aftercare through its out-patient and hospital facilities. A training program for parents also will be offered to help them care for children after they return home.

"We can't hope to cure the cerebral palsy child," Dr. Masten emphasizes. "We can hope to make him more comfortable and help him lead a more productive life."

(*continued on page 50*)

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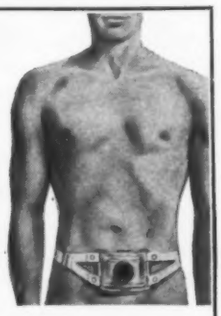

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(*continued from page 48*)

NOW, against one of the worst threats to the civilian population in case of war, a small device, no bigger than a man's index finger, is being added to emergency defense medical stockpiles. This device contains the antidote for a form of chemical warfare, held by many authorities to be capable of producing more widespread fatalities than the atom bomb. The threat is nerve gas. The device is a small disposable syringe called a syrette containing atropine.

The addition of this defense is another protective step against the agents that might be directed against civilians. It is one phase of the continually changing Civil Defense problem of protecting against the ever multiplying weapons of modern scientific warfare. If nerve gas is ever directed against this country, many U.S. citizens could die a violent death in a matter of minutes from a gas they will not see or smell.

Nerve gas is a lethal chemical and gets its name from its power to interfere with nervous system control over the muscles of the body.

Atropine is a drug which offsets the destructive action of nerve gas on the human nervous system, thereby eliminating the deadly physiologic effects of this chemical weapon. Other substances having capacity to block nerve gas in the blood have been found, but as of the moment atropine is the drug of choice.

The effectiveness of a nerve gas attack would depend on its scale, the weather, local terrain, density of population and, most important, on the extent to which Civil Defense has prepared defenses against chemical warfare. Nerve gas spreads rapidly and acts swiftly. It can be used in either liquid or vapor form. Speed is all important in exercising protective measures. Fortunately, although colorless and odorless, the presence of nerve gas can be detected by means of indicators that give a striking color change or that register an electrical alarm. The Manual on Civil Defense issued by the Federal Agency recommends prompt injection of atropine as the protective measure against nerve gas, and its inclusion in stockpiles of emergency medical supplies is recommended to Civil Defense authorities.

The syrette makes possible prompt treatment on a wide scale even under conditions of confusion and emergency resulting from an attack on the civilian population. The name Syrette is the tradename of a small disposable syringe developed by E. R. Squibb & Sons; it is manufactured only by that company. While it is not the only emergency dosage device available, it is perhaps the simplest for this purpose.

THE Eighteenth Annual Meeting of the American College of Chest Physicians will be held at the Congress Hotel, Chicago, Illinois, June 5 through 8, 1952. A scientific program covering all recent developments in the treatment of heart and lung disease is being arranged.

The Board of Examiners of the American College of Chest Physicians announces that the next oral and written examinations for Fellowship will be held in Chicago on June 5, 1952. Candidates for Fellowship in the College who wish to take the examinations should contact the Executive Secretary, American College of Chest Physicians, 112 East Chestnut Street, Chicago 11, Illinois.

THE Foundation of the American Society of Plastic and Reconstructive Surgery announced the winners of this year's awards in its Competitive Essay, at the Annual Meeting of the Society in Colorado Springs, October 30–November 1, 1951.

Dr. Richard B. Stark, New York City, won a Scholarship Award for his essay: "The Cross-Leg Flap Procedure." Dr. Kathryn Lyle Stephenson, Santa Barbara, California, Essay: "The Production of Ectopic Cartilage," received Honorable Mention.

Dr. Michael N. Tempest, Leeds, Yorkshire, England, Essay: "Cross-Finger Flaps in the Treatment of Injuries to the Finger Tip," won Honorable Mention. Dr. Allyn J. McDowell, North Hollywood, California, Essay: "Mass Treatment of Burns in Atomic Warfare," won Honorable Mention.

The Award Committee consisted of Drs. Robert H. Ivy, (Philadelphia) Neal Owens, (New Orleans) Kenneth L. Pickrell (Durham, N. C.) Lyndon A. Peer (Newark) Clarence R. Straatsma (New York) and Jacques W. Maliniac, Ex-Officio. (New York.)

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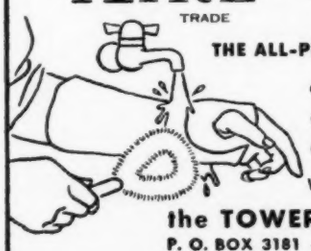

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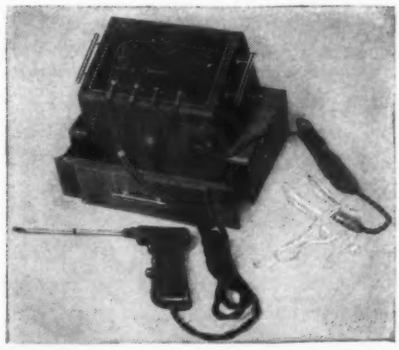

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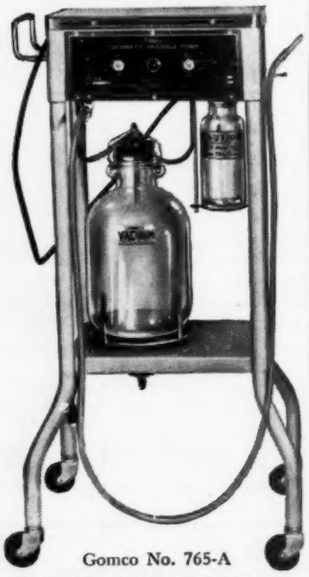

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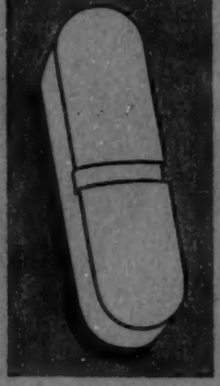

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